

**Instruction Manual**  
**No. EB 2300B**  
**for**  
**FM/AM Modulation Meter**  
**TF 2300B**

*Model No. 52300-920*

©

1974

**MARCONI INSTRUMENTS LIMITED**  
**ST. ALBANS HERTFORDSHIRE ENGLAND**

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EB 2300B  
1N-6/83



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## ELECTRICAL SAFETY PRECAUTIONS

This equipment is protected in accordance with IEC Safety Class 1. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

### Defects and abnormal stresses

Whenever it is likely that protection has been impaired, for example as a result of damage caused by severe conditions of transport or storage, the equipment shall be made inoperative and be secured against any unintended operation.

### Removal of covers

Removal of the covers is likely to expose live parts although reasonable precautions have been taken in the design of the equipment to shield such parts. The equipment shall be disconnected from the supply before carrying out any adjustment, replacement or maintenance and repair during which the equipment shall be opened. If any adjustment, maintenance or repair under voltage is inevitable it shall only be carried out by a skilled person who is aware of the hazard involved.

Note that capacitors inside the equipment may still be charged when the equipment has been disconnected from the supply. Before carrying out any work inside the equipment, capacitors connected to high voltage points should be discharged; to discharge mains filter capacitors, if fitted, short together the L (live) and N (neutral) pins of the mains plug.

### Mains plug

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension lead without protective conductor. Any interruption of the protective conductor inside or outside the equipment is likely to make the equipment dangerous.

### Fuses

Note that there is a supply fuse in both the live and neutral wires of the supply lead. If only one of these fuses should rupture, certain parts of the equipment could remain at supply potential.

To provide protection against breakdown of the supply lead, its connectors, and filter where fitted, an external supply fuse (e.g. fitted in the connecting plug) should be used in the live lead. The fuse should have a continuous rating not exceeding 6 A.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders shall be avoided.

### RADIO FREQUENCY INTERFERENCE

This equipment conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference

# General information

## 1.1 INTRODUCTION

The TF 2300B Modulation Meter measures f.m. deviation and a.m. depth. With its wide range of deviation frequency, modulation bandwidth and carrier frequency, the instrument is suitable for application to fixed and mobile point-to-point communications, broadcasting, telemetry and multi-channel link equipment in the h.f., v.h.f. and u.h.f. bands. Distortion and channel separation tests on f.m. stereo transmitters can also be made.

Positive and negative f.m. deviation can be measured in ranges from 1.5 kHz to 500 kHz full-scale at modulation frequencies between 30 Hz and

3.4 kHz on the 1.5 kHz deviation range, and 30 Hz and 200 kHz on all other deviation ranges. AM depth can be measured up to 95% in a 30 Hz to 50 kHz modulation bandwidth. Either f.m. or a.m. can be measured in the presence of the other. Although measurements are normally made by means of the meter readout, i.f. and demodulated outputs are available at the front panel for examination or analysis.

Spurious a.m. and f.m. due to hum and noise are kept to a level insignificant for most applications but, where required, an optional crystal oscillator can be fitted, or an external local oscillator may be used. The instrument can be operated without a local oscillator for measurements in the 1 to 2 MHz range.



Fig. 1.1 FM/AM Modulation Meter TF 2300B with Crystal Oscillator TK 2302

## 1.2 DATA SUMMARY

### FM measurement

Carrier frequency range :	4 to 1200 MHz.
Deviation range :	Six ranges with full-scale indications of 1.5, 5, 15, 50, 150 and 500 kHz. Positive or negative deviation indication selected by a switch.
Modulation frequency :	30 Hz to 200 kHz on all ranges except the 1.5 kHz deviation range which is limited to 30 Hz to 3.4 kHz.
Accuracy :	$\pm 3\%$ of f.s.d. for deviations up to $\pm 500$ kHz and modulating frequencies between 30 Hz and 150 kHz. $\pm 5\%$ of f.s.d. on the 1.5 kHz deviation range. $\pm 10\%$ of f.s.d. for deviations up to 500 kHz and for modulating frequencies between 150 kHz and 200 kHz.
AM rejection :	Additional deviation error typically less than 150 Hz in a 15 kHz bandwidth when the a.m. depth is 80% and the modulating frequency is 1 kHz.
Inherent noise :	Deviation less than -50 dB relative to a level of 5.0 kHz deviation in a -3 dB bandwidth of 50 Hz to 15 kHz from 4 to 200 MHz (typically -56 dB); less than -40 dB from 200 to 1038 MHz (typically -46 dB).

### AM measurement

Carrier frequency range :	4 to 400 MHz.
Modulation depth range :	Two ranges with full-scale indications of 30% and 100%. Peak and trough indications selected by a switch.
Accuracy :	$\pm 3\%$ of f.s.d. for modulating frequencies between 30 Hz and 15 kHz, and modulation depths up to 80%. $\pm 5\%$ of f.s.d. for modulating frequencies between 30 Hz and 50 kHz, and modulation depths up to 95%.

### RF input

Frequency range :	4 MHz to 1200 MHz in 11 bands as follows : 4 to 8, 8 to 15, 15 to 27, 27 to 48, 48 to 84, 84 to 147, 147 to 255, 255 to 426, 426 to 650, 650 to 1038 and 1038 to 1200 MHz. Usable with reduced sensitivity up to 1600 MHz with internal oscillator and at higher frequencies with an external oscillator.
Calibration accuracy :	$\pm 3\%$ .
Sensitivity :	Less than 12 mV between 4 and 426 MHz (typically 5 mV). Less than 35 mV between 426 and 1038 MHz (typically 15 mV). Less than 100 mV between 1038 and 1200 MHz (typically 50 mV).
Maximum input :	3 V r.m.s. (200 mW).
Input impedance :	Nominally 50 $\Omega$ .

## IF output

Frequency : Nominally 1.5 MHz.

Amplitude : Between at least 220 mV and 1 V e.m.f.

Output impedance : Nominally 10 kΩ.

## LF output

Frequency range : 30 Hz to 200 kHz with switchable 15 kHz low-pass filter for f.m. ranges 5, 15, 50, 150 and 500 kHz.

30 Hz to 3.4 kHz on the 1.5 kHz deviation range.

30 Hz to 50 kHz on a.m. (Typical response curves are shown in Fig. 1.2.)

Noise filter : Modifies response to a nominal -3 dB bandwidth of 50 Hz to 15 kHz for noise measurements at output terminals only. Usable for f.m. and a.m.

Stereo : Channel separation typically 44 dB from 200 Hz to 15 kHz decreasing to 39 dB at 50 Hz. Suitable for measurements on stereo transmitters designed to meet FCC regulations and CCIR Report 293-2.

De-emphasis : Switchable to 0, 50, 75 or 750 µs.

Output level : Nominally 0 dBm into 600 Ω when meter reads full-scale, except on the 1.5 kHz deviation range when the output is nominally -10 dBm.

Distortion, f.m. : Less than 0.2% for f.m. deviations up to ±75 kHz and modulating frequencies up to 15 kHz. (Typically 0.1%).  
Less than 1% for f.m. deviations up to ±300 kHz and modulating frequencies up to 25 kHz. (Typically less than 0.5%).  
Less than 3% for f.m. deviations up to ±500 kHz and modulating frequencies up to 200 kHz. (Typically 2%).

Distortion, a.m. : Less than 1% for a.m. depths up to 80%. (Typically 0.5% up to 60% depth.)  
Less than 2% for a.m. depths between 80% and 90%. (Typically 1.0% between 60% and 90% depth.)

*less than*

*less than*

*less than*

## Power requirements

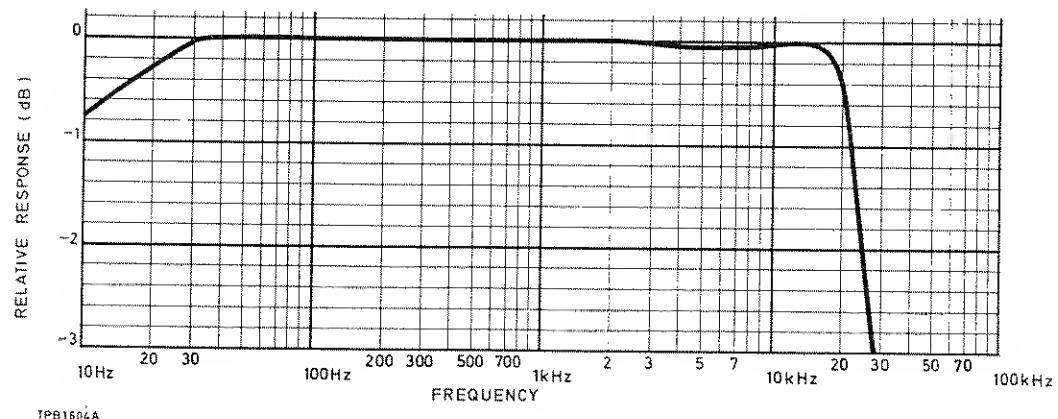
AC mains : 95 V to 130 V or 190 V to 260 V, 45 to 500 Hz.

Power consumption : 12 VA.

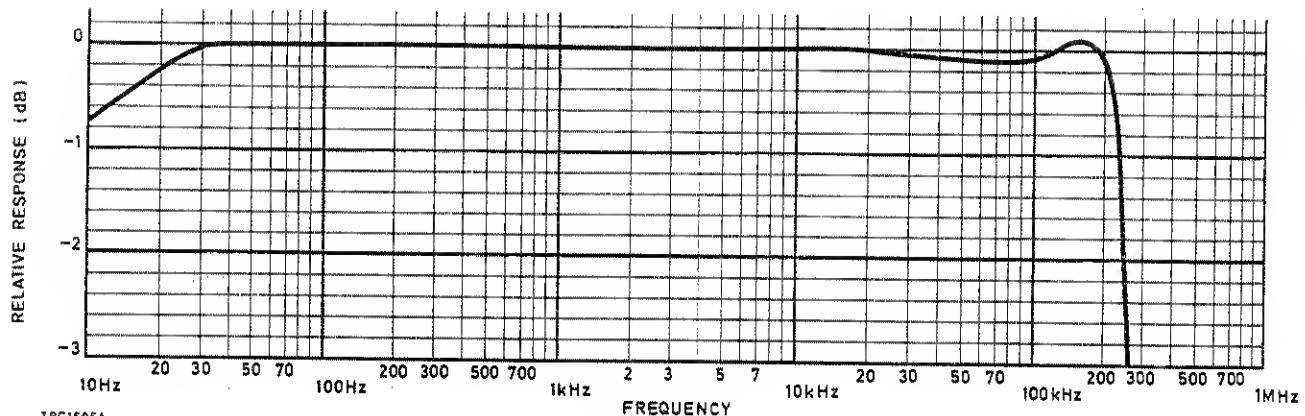
## Dimensions and weight

Height	Width	Depth	Weight
175 mm (7 in)	426 mm (16 3/4 in)	380 mm (15 in)	12.5 kg (27.5 lb)

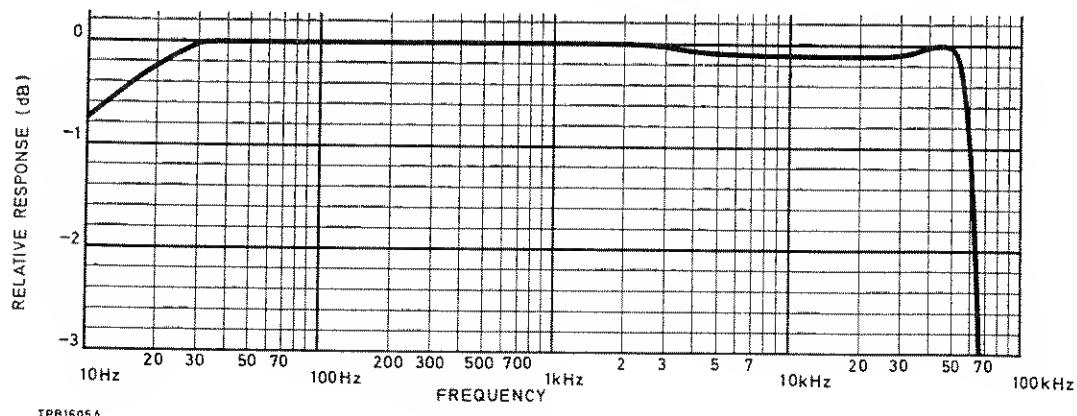
Fig. 1.2 Typical demodulated frequency response curves for meter and l.f. output with de-emphasis off



(a) FM, 15 kHz filter



(b) FM, 200 kHz filter



(c) AM, 50 kHz filter

### 1.3 ACCESSORIES

#### Supplied

44688-003 EXTENSION BOARD, TM 7926

For use when servicing printed circuit boards. Stowed internally - see Fig. 4.1.

43129-003 MAINS LEAD, TM 7052.

#### Optional

52302-900 CRYSTAL OSCILLATOR, TK 2302

Provides an alternative to the internal variable local oscillator, particularly for low noise measurements at high frequencies. Fits into the recess in the front panel.

Frequency range : 80 to 1000 MHz for f.m., 80 to 400 MHz for a.m.

Sensitivity : Less than 1.2 mV between 80 and 500 MHz (typically 5 mV).  
Less than 100 mV between 500 and 1000 MHz (typically 30 mV).

FM noise : Deviation relative to a level of 5 kHz deviation in a 3 dB bandwidth of 50 Hz to 15 kHz is less than :

-52 dB up to 800 MHz (typically -56 dB),  
-50 dB from 800 to 1000 MHz (typically -55 dB).

Crystals : Up to three switch selected crystals may be used. Marconi type QO 1670 series, in fundamental frequency range 40 to 60 MHz.

54452-011 SIGNAL SNIFFER

T connector for insertion between transmitter and load with pick-up to give a small signal from the T branch to the modulation meter.

Attenuation : Dependent upon frequency. Approximate range is -66 dB at 4 MHz, -50 dB at 25 MHz, -24 dB at 500 MHz, -18 dB at 1000 MHz when terminated by 50 Ω.

Dimensions : 66 mm x 66 mm x 15 mm (2.6 in x 2.6 in x 0.6 in).

54431-021 20 W, 50 Ω, 20 dB ATTENUATOR

Attenuator for use with signal sniffer where additional attenuation and/or termination is required with transmitters up to 30 W.

Attenuation : 20 dB nominal.

Frequency range : DC to 1 GHz.

Impedance : 50 Ω nominal.

Rating : 20 W continuous. 30 W for up to 5 minutes with off periods of at least 5 minutes.

Connectors : 50 Ω, BNC plug to BNC socket.

Dimensions : 66.4 mm long x 38 mm dia. nominal (2.625 in x 1.5 in nominal).

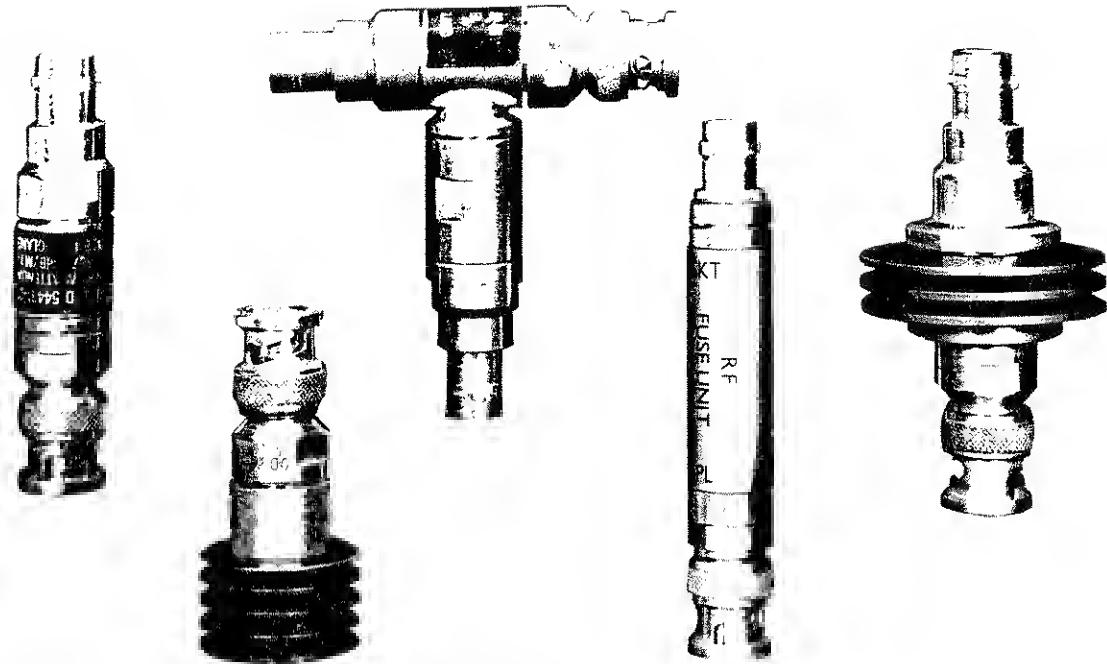


Fig. 1.3 1 W 50  $\Omega$  20 dB Attenuator, 12 W 50  $\Omega$  Termination, Signal Sniffer, RF Fuse Unit and 20 W 50  $\Omega$  20 dB Attenuator

54431-011 1 W, 50  $\Omega$ , 20 dB ATTENUATOR

Attenuator for use with signal sniffer or where termination is required with transmitters up to 1 W.

Attenuation :	20 dB nominal.
Frequency range :	DC to 1 GHz.
Impedance :	50 $\Omega$ nominal.
Rating :	1 W continuous.
Connectors :	50 $\Omega$ , BNC plug to BNC socket.
Dimensions :	66 mm long x 16.5 mm dia. nominal (2.6 in x 0.65 in nominal).

54422-011 12 W, 50  $\Omega$  TERMINATION

Termination for use as a good non-radiating termination for transmitters up to 15 W.

Impedance :	50 $\Omega$ nominal.
Frequency range :	DC to 1 GHz.
Rating :	12 W continuous. 15 W for up to 5 minutes, with off periods of at least 5 minutes.
Connector :	50 $\Omega$ , BNC plug.
Dimensions :	50 mm x 25 mm nominal (2 in x 1 in nominal).

Fuse for protection against accidental overload.

VSWR : Better than 1.4 :1 up to 500 MHz.

Insertion loss : Better than 0.75 dB at 300 MHz.  
Better than 1.25 dB at 500 MHz.

Rating : 0.4 W.

Connectors : 50  $\Omega$ , BNC plug to BNC socket.

Dimensions : 88 mm x 14 mm (3.5 in x 0.55 in).

54127-131 RACK MOUNTING CONVERSION KIT

Adapts the instrument for use in a 19 inch rack.

41690-079 PROTECTIVE FRONT PANEL COVER

For protection of the front panel during transit.

43126-012 INPUT LEAD, TM 4969/3

50  $\Omega$ , 1.57 m (62 in) long, BNC connectors.

**WARNING**

54431-021 20 W, 50  $\Omega$  20 dB ATTENUATOR

54422-011 12 W, 50  $\Omega$  TERMINATION

Beryllia is used in the internal construction of these accessories. This material when in the form of fine dust or vapour and inhaled into the lungs can cause a respiratory disease. Because of this hazard, you are strongly advised not to open the accessory. If a fault is suspected the accessory must be returned for repair to Marconi Instruments Service Division, or disposed of in such a manner that no health hazard will result.



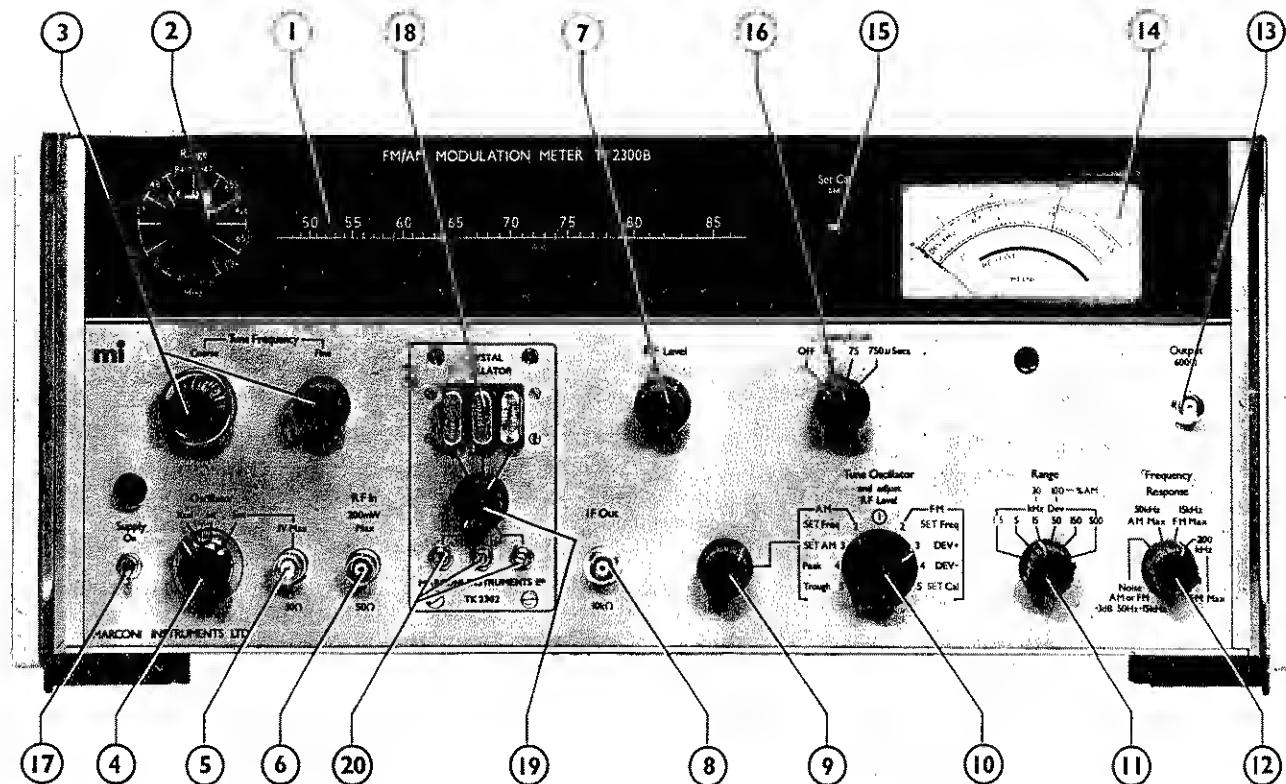


Fig. 2.1 Front panel controls and connectors

(13) OUTPUT socket. Type BNC. Provides demodulated output for connection to extra-sensitive meter, wave analyser etc.

(14) Meter. Reads % a.m. depth and f.m. deviation. RF LEVEL arc applies to position 1 of FUNCTION switch, and SET mark to the four SET positions.

(15) SET CAL FM preset. Standardizes deviation measuring accuracy. Adjust for SET reading on meter with FUNCTION switch at SET CAL.

(16) DE-EMPHASIS switch. Applies de-emphasis to demodulated signal at OUTPUT socket. Does not affect meter readout, except on 1.5 kHz deviation range.

(17) SUPPLY switch. Lamp indicates that supply is on.

Rear panel :

Supply plug. Accepts Mains Lead type TM 7052.

Mains fuse. 100 mA (for 230 V) or 160 mA (for 110 V) slow-blow type.

Mains voltage selector. 230 V position for 190 - 260 V, 110 V position for 90 - 130 V. Reverse locking plate when changing range.

Crystal Oscillator TK 2302 :

(18) CRYSTAL sockets. Accept style D miniature crystals for local oscillator control. See Sect. 2.11 for crystal selection.

(19) CRYSTAL switch. Selects crystal required and corresponding tuning preset.

(20) CRYSTAL tuners. Select correct crystal overtone.

## 2.4 PREPARATION FOR USE

It is helpful in reading these instructions and in using the instrument until completely familiar with its operation, to remember that where a control or switch position is marked SET, the control should be adjusted to make the meter read on the line marked SET.

Before commencing measurements :

- (1) Check the mechanical zero of the meter and adjust, if necessary, by means of the screw.

Note. When set to TUNE or SET AM and with no r.f. input, the meter will read slightly backwards. This is normal and is due to the bias on the AM detector diode.

- (2) Turn the RF LEVEL control towards the minimum necessary for the signal level.

- (3) Connect the signal to be tested to the RF IN socket at a level which, operating into  $50 \Omega$ , will develop a voltage within the limits given in Sect. 1.2 under 'RF input'. At the highest carrier frequencies the shortest possible input lead should be used or an external  $50 \Omega$  matching attenuator.

**CAUTION** Inputs greater than 3 V r.m.s. may damage the attenuator. If in doubt, use an external attenuator or RF Fuse Unit TM 9884.

- (4) Switch on the SUPPLY and check that the red lamp glows.

## 2.5 MEASURING FM DEVIATION

After carrying out the preparation procedure in Sect. 2.4 :

Note. Before carrying out a series of measurements, and from time to time during measurements, switch to SET CAL and check that the meter reads SET. If necessary, adjust the f.m. calibration by inserting a screwdriver in the SET CAL FM preset and adjusting until the meter reads SET.

- (1) Set the MODULATION RANGE switch to suit the expected deviation of the signal under test.

- (2) Set the FREQUENCY RESPONSE switch to 200 kHz unless the modulating frequency is less

than 15 kHz. If so, switch to 15 kHz in order to obtain the best signal-to-noise ratio.

(3) Set the DE-EMPHASIS switch as required. Its setting has no effect on the internal meter reading unless the MODULATION RANGE switch is in the 1.5 kHz deviation position. The de-emphasis is effective on the demodulated signal at the OUTPUT socket.

(4) Set the FREQUENCY RANGE switch to suit the carrier frequency of the signal. For detailed instructions on oscillator arrangements, see Sect. 2.10. In this section, it is assumed that the internal local oscillator will be used.

(5) Set the FUNCTION switch to TUNE OSCILLATOR. Swing the TUNE FREQUENCY coarse control to find the response on the meter and if necessary adjust the RF LEVEL control to avoid meter readings which are greater than f.s.d. Two peaks should be found on the meter. Tune to the higher frequency peak using the fine control.

(6) Set the FUNCTION switch to FM SET FREQUENCY. Slightly readjust the TUNE FREQUENCY controls until the meter deflects to the SET line. Avoid spurious settings - the correct one is that closest to the original setting obtained in (5).

(7) Set the FUNCTION switch to DEV+ and DEV-. The demodulated peak frequency deviations above and below the carrier frequency may be measured on the meter or viewed on an oscilloscope connected to the OUTPUT socket. Read the meter on the scale corresponding to the setting of the MODULATION RANGE switch.

Note. If unequal readings are obtained, distortion in the equipment under test is indicated. See Sect. 2.13.

**CAUTION** Do not attempt to SET CAL on the 1.5 kHz f.m. deviation range.

## 2.6 MEASURING AM DEPTH

After carrying out the preparation procedure in Sect. 2.4 :

- (1) Set the MODULATION RANGE switch to the 30% or 100% a.m. depth range according to the expected modulation depth of the signal under test.

(2) Set the FREQUENCY RESPONSE switch to 50 kHz.

(3) Set the FREQUENCY RANGE switch to suit the carrier frequency of the signal. For detailed instructions on oscillator arrangements, see Sect. 2.10. In this section, it is assumed that the internal local oscillator will be used.

(4) Set the FUNCTION switch to TUNE OSCILATOR. Adjust the tuning dial to the carrier frequency. Tune for peak deflection and then adjust the RF LEVEL control to give a meter deflection below the AM MAX line in the black RF LEVEL arc, preferably towards the lower end of the arc for best mixing and hence minimum distortion.

(5) Set the FUNCTION switch to AM SET FREQ. Slightly readjust the TUNE FREQUENCY controls until the meter deflects to the SET line. Avoid spurious settings - the correct one is that closest to the original setting obtained in (4).

(6) Set the FUNCTION switch to SET AM. Adjust the adjacent SET AM control until the meter reads on the SET line. Note that this setting can be done with or without modulation since the adjustment is to the mean level of the i.f. signal. However, appreciable even harmonic distortion can affect the setting accuracy and, in such circumstances, it is preferable to set up with modulation.

(7) Set the FUNCTION switch to AM PEAK. Read the percentage modulation depth at the peak.

(8) Set the FUNCTION switch to AM TROUGH. Read the percentage modulation depth at the trough.

When the peak and trough readings are unequal, distortion is present in the input signal.

## 2.7 MEASURING FM ON AM

To measure the spurious f.m. on an amplitude modulated source, proceed as for f.m. measurement, Sect. 2.5.

A certain amount of spurious f.m. is introduced by the instrument itself. When the carrier is deeply modulated, at high modulating frequencies, this should be taken into consideration, but below 40% depth in the audio range of frequencies the spurious deviation is not very significant. At

80% depth and 1 kHz frequency, the maximum spurious deviation is typically less than 150 Hz referred to the 15 kHz bandwidth.

Tables 2.1 and 2.2 give typical results which should be used for general guidance purposes only.

TABLE 2.1

*Spurious deviations with increasing % a.m.*

1. RF LEVEL control set for meter reading at the AM MAX line.
2. AM frequency = 1 kHz.

*Spurious deviation*

% a.m.	15 kHz bandwidth	200 kHz bandwidth
30%	75 Hz	750 Hz
80%	150 Hz	2 kHz

TABLE 2.2

*Spurious deviations with increasing a.m. frequency*

1. RF LEVEL control set for meter reading at the AM MAX line.
2. AM depth = 80%.

*Spurious deviation*

AM frequency	15 kHz bandwidth	200 kHz bandwidth
1 kHz	150 Hz	2 kHz
10 kHz	2 kHz	3 kHz
100 kHz	-	7 kHz

## 2.8 MEASURING AM ON FM

The modulation meter may be used to indicate amplitude modulation in a frequency modulated signal, provided that the deviation is less than 100 kHz. The procedure is that of a.m. measurement, Sect. 2.6.

In general, the spurious a.m. indication will be proportional to the deviation. The i.f. amplifier is set up for optimum phase response for f.m. deviation measurement rather than a maximally flat response for measuring a.m. on f.m.

Below 100 kHz deviation, the internally generated spurious a.m. is less than 5% approximately.

## 2.9 NOISE MEASUREMENTS

By connecting an external meter to the OUTPUT socket, noise measurements limited only by the noise level generated within the instrument can be made. The internal meter, being peak reading, is not suitable for measuring noise and, ideally, an r.m.s. responding meter should be used. However, sufficiently accurate results are usually obtained with an average reading meter by applying the appropriate correction factor.

Typical meters which can be used are as follows :

(a) RMS electronic voltmeter capable of measuring to the necessary accuracy (1% of full-scale deviation gives approximately 7.75 mV on any range except 1.5 kHz f.s.d. where the level is about 2.45 mV). Errors due to crest factor and zero shift can be avoided by operating the meter at mid-scale by means of an attenuator.

(b) Marconi Instruments Sensitive Valve Voltmeter, type TF 2600.

(c) Marconi Instruments Distortion Factor Meter, type TF 2331.

(b) and (c) are average reading and a correction of +1 dB should be applied.

For normal noise measurements the FREQUENCY RESPONSE switch should be in the NOISE position, which gives a 3 dB bandwidth of 50 Hz to 15 kHz (except on the 1.5 kHz deviation range).

For narrow band measurements the DE-EMPHASIS switch can be used to limit the upper frequency; for example, the 50  $\mu$ s position gives a response of -3 dB at 3.15 kHz. Alternatively, use the 1.5 kHz deviation range which gives a restricted bandwidth of 30 Hz to 3.4 kHz.

For wide band measurements use the 200 kHz position of the FREQUENCY RESPONSE switch and limit the top frequency by a capacitor or filter across the OUTPUT socket. A capacitor of 0.0015  $\mu$ F gives a response of -3 dB at 200 kHz, or a low-pass filter can be chosen to give the required lower cut-off frequency.

The output of the modulation meter is 0.775 V into 600  $\Omega$  for full-scale deflection on the internal meter (0.245 V on the 1.5 kHz deviation range).

For measurements above about 200 MHz the Crystal Oscillator TK 2302 should be used if lowest possible internally generated noise is required. Thus, a crystal suitable for the appropriate frequency must be available.

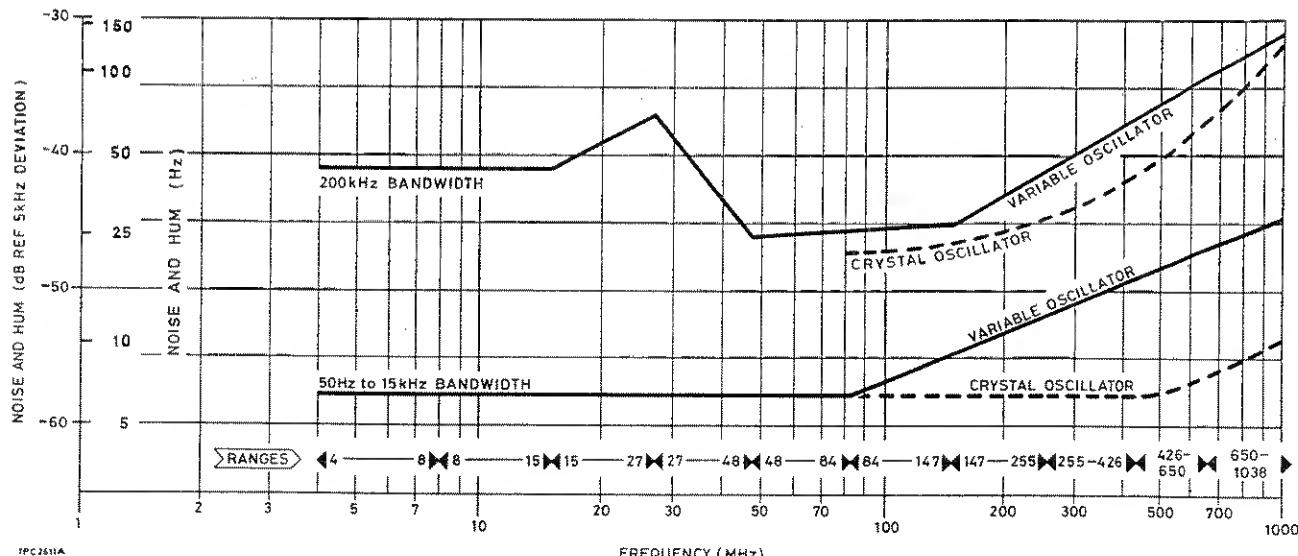


Fig. 2.2 Typical noise level of instrument

The curves given in Fig. 2.2 show typical noise levels produced by the internal oscillator and Crystal Oscillator TK 2302 over the r.f. range of the instrument. In the 'noise' bandwidth, below 100 MHz, there is insignificant difference in respective noise levels. Above 100 MHz, however, the noise level using the internal oscillator increases progressively with frequency, whereas with the crystal oscillator the level remains nearly constant. The necessity to use the crystal oscillator depends on the noise level of the equipment under test and, as shown by the curves, the bandwidth in which the measurement is to be made and the carrier frequency. In the 200 kHz bandwidth, there is little advantage in using the crystal oscillator.

In both bandwidths, crystal control will eliminate oscillator microphony and therefore may be advantageous in conditions of vibration or high acoustic noise levels.

#### FM noise

- (1) Connect an external meter to the OUTPUT socket. Apply r.f. input at a suitable level.
- (2) Adjust the tuning dial to the signal frequency and tune for peaking, as in Sect. 2.5 (5). Then adjust the RF LEVEL control for a reading towards the top end of the black arc on the internal meter.
- (3) Switch to the appropriate FREQUENCY RESPONSE setting, as described above, thus selecting the required bandwidth. For low noise measurement, particularly on the 200 kHz bandwidth, it is advisable to minimize the inherent noise in the modulation meter by adjusting the RF LEVEL control until minimum noise is indicated on the external meter (even if this causes the meter to deflect beyond full-scale when the FUNCTION switch is at SET LEVEL - see (7)).
- (4) Switch to position FM SET FREQ. and adjust the oscillator until the meter reads SET.
- (5) Switch to DEV+. Modulate the carrier to the reference deviation and select the appropriate range on the MODULATION RANGE switch.
- (6) Read the external meter and record the dB level.
- (7) Remove the modulation from the signal under test. Turn the MODULATION RANGE switch to

the 5 kHz range and then increase the sensitivity of the external meter to give a convenient reading. Adjust the RF LEVEL control so that this reading is at a minimum. Record the new level, which is given by the reading on the external meter plus 10 dB for each step traversed by the MODULATION RANGE switch.

- (8) The signal-to-noise ratio referred to the selected bandwidth in which the measurements were made is given by the difference between the levels measured in (6) and (7).

#### AM noise

- (1) Connect an external meter to the OUTPUT socket. Apply r.f. input at a suitable level.
- (2) Adjust the tuning dial to the signal frequency and tune for peaking, as in Sect. 2.6(3). Then adjust the RF LEVEL control to give a meter deflection at the AM MAX mark (or as near to it as possible with a low level input).
- (3) Switch to the appropriate FREQUENCY RESPONSE setting, as described above, thus selecting the required bandwidth.
- (4) Switch to position AM SET FREQ and adjust the oscillator until the meter reads SET.
- (5) Switch to SET AM and adjust the SET AM level control for a meter reading at the SET mark.
- (6) Switch to AM PEAK. Modulate the carrier to the reference depth and select the appropriate a.m. range on the MODULATION RANGE switch. Since 100% modulation is impracticable, use some other level and correct the result accordingly, e.g. use 50% modulation and add -6 dB to the noise reading to obtain a result relative to 100% modulation.
- (7) Read the external meter and record the dB level.
- (8) Remove the modulation from the signal under test. Turn the MODULATION RANGE switch to the 30% range and then increase the sensitivity of the external meter to give a convenient reading. Record the new level, which is given by the reading on the external meter plus 10 dB for each step traversed by the MODULATION RANGE switch.
- (9) The signal-to-noise ratio is given by the difference between the levels measured in (6) and (7).

## 2.10 OSCILLATOR ARRANGEMENTS AND OPERATING NOTES

The same procedure applies for both f.m. and a.m. measurements. The basic requirement is for a stable frequency source 1.5 MHz higher than the signal under test, and this can be obtained from three sources :

- (a) The internal variable oscillator usable at all frequencies between 4 and 1200 MHz.
- (b) An external oscillator with an output of about 200 mV across  $50\ \Omega$ .
- (c) The optional CRYSTAL OSCILLATOR type TK 2302 - for details see Sect. 2.11.

### 2.10.1 Internal oscillator

Turn the OSCILLATOR selector to INT, and choose the appropriate range switch.

Adjust the tuning dial with the coarse control to the carrier frequency of the input signal. Then adjust the coarse and/or fine controls for peak meter deflection. Note that there are two tuning points at which the meter peaks, corresponding to local oscillator frequencies 1.5 MHz above and below the input carrier frequency; always tune to the peak at the higher frequency tuning point for correct polarity sense of the FUNCTION switch.

Adjust the fine control from time to time, to bring the meter reading to the SET mark when switched to the SET FREQ position. It is permissible to tune to another internal oscillator harmonic as this will not affect the readings obtained.

The oscillator takes about two minutes to stabilize after turning on, but this is only of any significance at very high frequencies.

### 2.10.2 External oscillator

If a stable frequency source is available, it may be preferable to use it rather than the internal oscillator. Feed the external oscillator signal into the EXT OSCILLATOR socket and turn the OSCILLATOR switch to EXT. An input level of about 200 mV into  $50\ \Omega$  is required at a frequency 1.5 MHz above the input signal frequency.

The primary use of this facility is for measurement on r.f. signals which contain harmonics of less than 20 dB down on the fundamental. Because the internal oscillator signal also contains harmonics, mixing two such signals can give rise to spurious results. A 'pure' local oscillator signal minimizes the risk.

Secondly, if an external crystal oscillator is available, it may be preferred to use this, rather than the internal crystal oscillator, for low level noise measurements.

### 2.10.3 Use above 1200 MHz

It is possible to use the instrument above 1200 MHz using the internal or external oscillator.

With the internal oscillator, higher harmonics are sufficiently present to cover the range 1200 to 1600 MHz at reduced sensitivity. Use the appropriate range with a scale indication of half the wanted frequency; for example, tune to 750 MHz for measurements at 1500 MHz.

Using a suitable external oscillator the carrier frequency range can be extended to about 2500 MHz, but the sensitivity may deteriorate.

## 2.11 USE OF CRYSTAL OSCILLATOR TK 2302

This section applies only when the instrument includes the optional crystal oscillator unit which fits in the front panel recess. The use of this oscillator is advantageous when making low noise measurements above about 200 MHz, or in conditions likely to cause microphony, or where operation is restricted to a few spot frequencies. Up to three crystals can be plugged in and any one selected by a switch.

### 2.11.1 Fitting the crystal oscillator

- (1) Remove the rectangular cover plate held by four M3 screws to the front panel.
- (2) Remove the bottom cover of the instrument.

(3) Insert the crystal oscillator unit in the front panel cut-out.

(4) Connect the coaxial plug and red wander plug to their mating sockets on the housing behind the OSCILLATOR selector.

(5) Secure the unit with the four fixing screws and replace the bottom cover.

Expressed as a formula :

$$\text{Crystal frequency} = \frac{(\text{RF} + 1.5) \text{ MHz}}{\text{Harmonic factor}}$$

NOTE. The r.f. input range of 38.5 to 58.5 MHz can also be crystal controlled by operating the crystal on its fundamental frequency (or to 61.5 MHz if positive and negative deviation are reversed).

### 2.11.2 Crystal selection

Crystals should be series resonant 3rd overtone types in the range 40 to 60 MHz.

Normal tolerance (200 p.p.m. from 0 to 60°C) is adequate except at the higher signal frequencies when 150 p.p.m. is recommended. If possible, all crystals should have similar equivalent series resistance, ideally  $35 \Omega \pm 5\%$ . If the e.s.r. is substantially different from this, adjustment of the crystal drive may be required by selecting a new value for R8 (increase resistance if e.s.r. is high).

Recommended crystals are :

Range (MHz)	Marconi type
40 to 44.999	QO 1670F/150/A/S
45 to 54.999	QO 1670G/150/A/S
55 to 60	QO 1670K/150/A/S

These crystals are in hermetically sealed, style D miniature cases (US style HC6U).

The required crystal frequency for any r.f. input between 80 and 1000 MHz can be calculated by the following procedure :-

(1) Add 1.5 MHz to the r.f. input frequency to obtain the harmonic frequency of the crystal.

(2) Divide this sum by the crystal harmonic factor given in Table 2.3 against the applicable r.f. input frequency range. The result is the crystal fundamental frequency.

TABLE 2.3

RF input frequency (MHz)	Crystal harmonic factors	
	Crystal harmonic factor	Crystal fundamental range
38.5 - 58.5	1	40 - 60 MHz
80 - 118.5	2	
118.5 - 178.5	3	
178.5 - 238.5	4	
238.5 - 298.5	5	
298.5 - 358.5	6	
358.5 - 418.5	7	
418.5 - 478.5	8	
478.5 - 538.5	9	
538.5 - 598.5	10	
598.5 - 658.5	11	
658.5 - 718.5	12	
718.5 - 778.5	13	
778.5 - 838.5	14	
838.5 - 898.5	15	
898.5 - 958.5	16	
958.5 - 1000	17	

Example : To find the fundamental crystal frequency for an r.f. input of 461.4 MHz.

From Table 2.3, it can be seen that this r.f. is within the range corresponding to a crystal harmonic factor of 8.

$$\text{Therefore crystal frequency} = \frac{461.4 + 1.5}{8}$$

$$= 57.8625 \text{ MHz.}$$

A frequency of 57.86 MHz would be sufficiently precise, having regard to the tolerance of the crystal specification and the bandwidth of the i.f. Crystals are fully specified in Data Sheets QO 1670F, -G and -K to which reference should be made for further details if required. Data sheets and crystals are available from the MI Service Division - for address see rear cover.

### 2.11.3 Crystal oscillator operation

(1) Plug in a crystal of the required frequency as selected in Sect. 2.11.2 and turn the CRYSTAL selector to the corresponding position. The capacitances of the crystals in the unused positions affect the adjustment of the oscillator. It is therefore recommended that crystals be inserted in all three positions since the oscillator is set up in the factory with three crystals.

(2) Apply the r.f. input signal at a suitable level.

(3) Turn the FUNCTION switch to position 1 and the OSCILLATOR switch to XTAL.

(4) Adjust the appropriate CRYSTAL TUNE preset for maximum meter deflection. If there is more than one peak, choose the one that gives the best results, e.g. the lowest noise. Thereafter proceed as for internal.

### 2.12 MEASUREMENT IN 1 TO 2 MHz RANGE

The instrument can accept signals in the band 1 to 2 MHz, applied directly to RF IN, with the oscillator off, i.e. switched to EXT. Input sensitivity is the same as usual. Ensure the modulation frequency does not take the frequency beyond the band limits quoted, so as to avoid introducing distortion caused by the reduced gain outside the pass band.

Operating the instrument in this way cuts out the frequency inversion caused by the heterodyne system normally used. The polarity of the DEV+ and DEV- positions of the FUNCTION switch is therefore reversed.

### 2.13 ASYMMETRIC MODULATION AND CARRIER SHIFT

The presence of asymmetric modulation usually indicates distortion in the equipment under test, and is revealed by unequal meter readings when the FUNCTION switch is turned between PEAK and TROUGH or DEV+ and DEV-.

In position SET FREQ, the output from a counter circuit in the limiter is measured by the meter. When the meter indicates SET, the i.f. is centred on 1.5 MHz exactly. If modulation then causes the meter reading to fluctuate, carrier

shift is present. The extent of the shift may be measured by connecting a counter to IF OUT. In cases of severe carrier shift, the modulation meter must be set up with modulation off.

### 2.14 USE OF LF OUTPUT SOCKET

**CAUTION** Application of d.c. to this socket may damage the associated electrolytic coupling capacitor.

This output enables the modulation waveform on the input signal to be monitored or analysed. It also enables a sensitive external meter to be used to extend the deviation range down to the level of residual noise within the instrument.

The socket is fed by an independent output stage in the 2nd l.f. amplifier and therefore the internal meter is unaffected by loads connected to it.

Depending on the position of the FUNCTION switch, demodulated a.m. or f.m. outputs are obtained. The frequency response of the LF OUTPUT is determined by the settings of the FREQUENCY RESPONSE and DE-EMPHASIS switches. The frequency response of the meter depends on the setting of the FREQUENCY RESPONSE switch only, except when the 1.5 kHz range is in use, where it is determined by the settings of both the FREQUENCY RESPONSE and DE-EMPHASIS switches.

The impedance of the LF OUTPUT is approximately  $600\ \Omega$ . With DE-EMPHASIS switched off, full scale deflection on the internal meter corresponds to an output level of 0 dBm, except on the 1.5 kHz range, where the output level is -10 dBm.

The l.f. response is substantially level up to 200 kHz. The output is also available with switched de-emphasis to restore the modulation characteristic of signals that have had pre-emphasis applied.

### 2.15 USE OF IF OUTPUT SOCKET

This socket can be used to measure carrier shift by connecting a counter to it - see Sect. 2.13 - or to view the a.m. envelope on an oscilloscope.

It may also be used to measure amplitude modulation above 50 kHz which normally would not be passed by the a.m. detector. This is an extended use of the modulation meter which in practice would probably be limited by the attenuation of the  $10\ k\Omega$  output resistance and the input capacitance of the measuring instrument.

The test arrangement for measuring distortion in an f.m. stereo transmitter is given below :-

Distortion and channel separation in stereo systems which are designed to meet CCIR Report 293-2 and US Federal Communications Commission (FCC) requirements can be measured with the TF 2300B Modulation Meter. The general procedures are described in the following sections.

### 2.16.1 Harmonic distortion

It can be assumed that distortion introduced by the modulation meter is small in comparison with that in stereo transmitters, being typically better than 0.1% for deviations up to  $\pm 75$  kHz and therefore, for practical purposes, can be ignored.

Fig. 2.3

The frequency spectrum of a GE-Zenith type of f.m. stereo signal when a 1 kHz test tone (for example) is applied to the left channel and no signal to the right, is shown in Fig. 2.3.

Ideally, only the fundamental 1 kHz signal in the left + right (L + R) channel and the 37 and 39 kHz sidebands of the suppressed sub-carrier in the L - R channel should be present. In practice, however, harmonic distortions will occur at 2, 3, 4 kHz .... in the L + R channel and at 36 and 40, 35 and 41, 34 and 42 kHz .... in the L - R channel. These are the distortion components which it is desired to measure.

(1) Connect the transmitter output to the modulation meter in accordance with Sect. 2.4 - Preparation for use.

(2) Set up the modulation meter with the transmitter signal on, in accordance with Sect. 2.5 - Measuring f.m. deviation.

The following notes are intended to amplify the setting instructions and refer specifically to the GE-Zenith system.

(3) Set the controls as follows :-

MODULATION RANGE : 150 kHz.

FREQUENCY RESPONSE : 200 kHz.

DE-EMPHASIS : OFF, even if pre-emphasis is being applied.

FUNCTION : DEV+ or DEV-.

(4) Apply a test signal of a chosen frequency to the left channel with no signal to the right channel.

(5) Connect Wave Analyser type TF 2330 series, or an equivalent instrument for harmonic analysis of the audio range, to the OUTPUT socket of the modulation meter. (Refer to the instruction manual on the analyser for calibration and measuring procedures.)

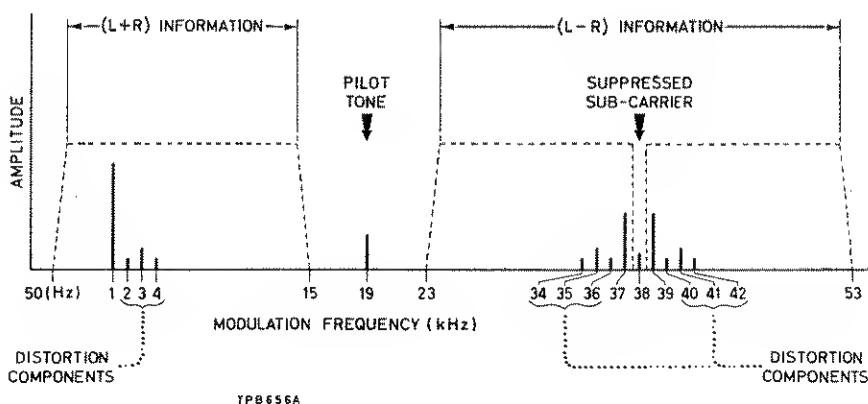


Fig. 2.3 Frequency spectrum of f.m. stereo signal with 1 kHz modulating tone

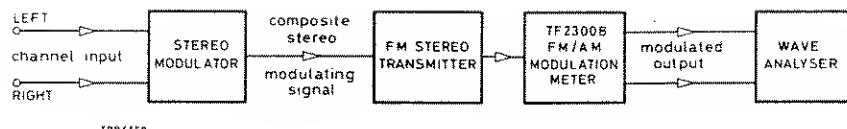


Fig. 2.4 Test arrangement for measuring distortion

(6) The frequency spectrum of the demodulated output of the modulation meter can be obtained by tuning through the frequency range and taking measurements at the appropriate frequencies. The result is usually referred to the fundamental and expressed as percentages or dB readings, calculated by the usual method for harmonic distortion measurement as described in the wave analyser manual.

For practical working purposes, the small amount of distortion introduced by the modulation meter can be neglected.

### 2.16.2 Channel separation

If it were possible to view the 50 Hz to 15 kHz and the 23 to 53 kHz regions of Fig. 2.3 separately, the waveforms shown in Figs. 2.5(a) and (b) would be seen.

The ideal composite modulating signal with the 19 kHz pilot tone removed should be the sum of these waveforms as shown in (c). In practice, there will be amplitude unbalance and relative phase shift (group delay error) between the two added signals. These two effects, which can be viewed on a direct coupled oscilloscope, are illustrated in (d) and (e), where amplitude 'B' represents a signal on the right channel due to an input on the left channel.

Channel separation is given by :

$$\text{Separation} = 20 \log_{10} \frac{A}{B} \quad \dots \dots \quad (1)$$

where A and B are measurements indicated in Figs. 2.5 (d) and (e).

An f.m. stereo transmitter or stereo modulator must meet specified requirements as regards

response and phase shift. In the FCC requirements, it is deemed that these are met if the channel separation exceeds 29.7 dB.

A suitable oscilloscope, such as a Marconi Instruments type TF 2210, connected to the OUT-PUT socket of the modulation meter, enables the channel separation to be measured.

From 200 Hz to 15 kHz, the channel separation figure of the modulation meter is typically 14 dB below the minimum required of f.m. stereo channels in the FCC regulations, while at 50 Hz (the worst condition), it is typically 10 dB below.

The test arrangement for measuring channel separation is as illustrated in Fig. 2.4, except that the wave analyser is now replaced by an oscilloscope, and the procedure is as follows :-

- (1) Set up the equipment and modulation meter as already described for distortion measurements.
- (2) Apply a test signal to the left channel at 15 kHz modulation frequency (for example) with no signal on the right channel.

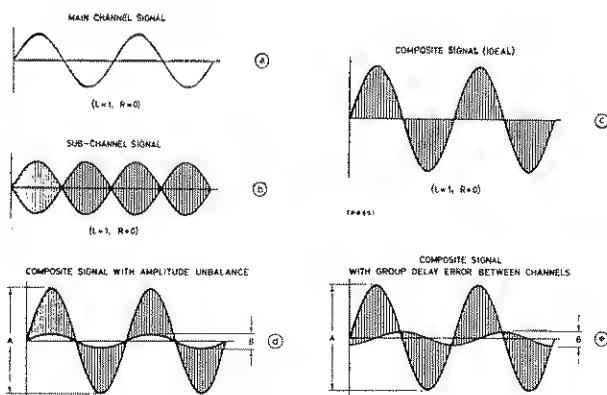


Fig. 2.5 Derivation of composite stereo signal showing unbalance and phase shift errors

(3) Connect the oscilloscope, switched to d.c. coupling, to the OUTPUT socket of the modulation meter. If the oscilloscope has a high input resistance it is advisable to connect a resistor of about  $1\text{ k}\Omega$  (the exact value is unimportant) in parallel with the oscilloscope input; this is to prevent leakage in the electrolytic output coupling capacitor of the modulation meter from producing a voltage which may shift the trace off the screen. Adjust the oscilloscope to suitable time base and input attenuator settings for a composite signal waveform. The procedure here depends on the equipment being tested; in general it consists of setting up the system for deviation, and gain etc., in accordance with individual system manufacturers' instructions until a satisfactory waveform is seen. The gain of the L-R channel should then be adjusted for minimum amplitude 'B'. Measure this amplitude and calculate separation in accordance with formula (1).

## 2.17 PHASE MODULATION

To find the degree of phase modulation, measure the deviation and divide by the modulating frequency to obtain the answer in radians.

## 2.18 TELEMETRY DEVIATION

To measure the deviations in a modulated telemetry signal connect the OUTPUT socket to the external meter via a switched series of band-pass filters at the sub-carrier frequencies. This enables the deviation due to each tone to be measured, having first calibrated the meter against a signal modulated by a single tone.

## Decibel conversion table

Ratio Down			Ratio Up		
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER	
1.0	1.0	.0	1.0	1.0	
.9886	.9772	.1	1.012	1.023	
.9772	.9550	.2	1.023	1.047	
.9661	.9333	.3	1.035	1.072	
.9550	.9120	.4	1.047	1.096	
.9441	.8913	.5	1.059	1.122	
.9333	.8710	.6	1.072	1.148	
.9226	.8511	.7	1.084	1.175	
.9120	.8318	.8	1.096	1.202	
.9016	.8128	.9	1.109	1.230	
.8913	.7943	1.0	1.122	1.259	
.8710	.7586	1.2	1.148	1.318	
.8511	.7244	1.4	1.175	1.380	
.8318	.6918	1.6	1.202	1.445	
.8128	.6607	1.8	1.230	1.514	
.7943	.6310	2.0	1.259	1.585	
.7762	.6026	2.2	1.288	1.660	
.7586	.5754	2.4	1.318	1.738	
.7413	.5495	2.6	1.349	1.820	
.7244	.5248	2.8	1.380	1.905	
.7079	.5012	3.0	1.413	1.995	
.6683	.4467	3.5	1.496	2.239	
.6310	.3981	4.0	1.585	2.512	
.5957	.3548	4.5	1.679	2.818	
.5623	.3162	5.0	1.778	3.162	
.5309	.2818	5.5	1.884	3.548	
.5012	.2512	6	1.995	3.981	
.4467	.1995	7	2.239	5.012	
.3981	.1585	8	2.512	6.310	
.3548	.1259	9	2.818	7.943	
.3162	.1000	10	3.162	10.000	
.2818	.07943	11	3.548	12.59	
.2512	.06310	12	3.981	15.85	
.2239	.05012	13	4.467	19.95	
.1995	.03981	14	5.012	25.12	
.1778	.03162	15	5.623	31.62	

**Decibel conversion table (continued)**

Ratio Down			Ratio up		
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER	
.1585	.02512	16	6.310	39.81	
.1413	.01995	17	7.079	50.12	
.1259	.01585	18	7.943	63.10	
.1122	.01259	19	8.913	79.43	
.1000	.01000	20	10.000	100.00	
.07943	$6.310 \times 10^{-3}$	22	12.59	158.5	
.06310	$3.981 \times 10^{-3}$	24	15.85	251.2	
.05012	$2.512 \times 10^{-3}$	26	19.95	398.1	
.03981	$1.585 \times 10^{-3}$	28	25.12	631.0	
.03162	$1.000 \times 10^{-3}$	30	31.62	1,000	
.02512	$6.310 \times 10^{-4}$	32	39.81	$1.585 \times 10^3$	
.01995	$3.981 \times 10^{-4}$	34	50.12	$2.512 \times 10^3$	
.01585	$2.512 \times 10^{-4}$	36	63.10	$3.981 \times 10^3$	
.01259	$1.585 \times 10^{-4}$	38	79.43	$6.310 \times 10^3$	
.01000	$1.000 \times 10^{-4}$	40	100.00	$1.000 \times 10^4$	
$7.943 \times 10^{-3}$	$6.310 \times 10^{-5}$	42	125.9	$1.585 \times 10^4$	
$6.310 \times 10^{-3}$	$3.981 \times 10^{-5}$	44	158.5	$2.512 \times 10^4$	
$5.012 \times 10^{-3}$	$2.512 \times 10^{-5}$	46	199.5	$3.981 \times 10^4$	
$3.981 \times 10^{-3}$	$1.585 \times 10^{-5}$	48	251.2	$6.310 \times 10^4$	
$3.162 \times 10^{-3}$	$1.000 \times 10^{-5}$	50	316.2	$1.000 \times 10^5$	
$2.512 \times 10^{-3}$	$6.310 \times 10^{-6}$	52	398.1	$1.585 \times 10^5$	
$1.995 \times 10^{-3}$	$3.981 \times 10^{-6}$	54	501.2	$2.512 \times 10^5$	
$1.585 \times 10^{-3}$	$2.512 \times 10^{-6}$	56	631.0	$3.981 \times 10^5$	
$1.259 \times 10^{-3}$	$1.585 \times 10^{-6}$	58	794.3	$6.310 \times 10^5$	
$1.000 \times 10^{-3}$	$1.000 \times 10^{-6}$	60	1,000	$1.000 \times 10^6$	
$5.623 \times 10^{-4}$	$3.162 \times 10^{-7}$	65	$1.778 \times 10^3$	$3.162 \times 10^6$	
$3.162 \times 10^{-4}$	$1.000 \times 10^{-7}$	70	$3.162 \times 10^3$	$1.000 \times 10^7$	
$1.778 \times 10^{-4}$	$3.162 \times 10^{-8}$	75	$5.623 \times 10^3$	$3.162 \times 10^7$	
$1.000 \times 10^{-4}$	$1.000 \times 10^{-8}$	80	$1.000 \times 10^4$	$1.000 \times 10^8$	
$5.623 \times 10^{-5}$	$3.162 \times 10^{-9}$	85	$1.778 \times 10^4$	$3.162 \times 10^8$	
$3.162 \times 10^{-5}$	$1.000 \times 10^{-9}$	90	$3.162 \times 10^4$	$1.000 \times 10^9$	
$1.000 \times 10^{-5}$	$1.000 \times 10^{-10}$	100	$1.000 \times 10^5$	$1.000 \times 10^{10}$	
$3.162 \times 10^{-6}$	$1.000 \times 10^{-11}$	110	$3.162 \times 10^5$	$1.000 \times 10^{11}$	
$1.000 \times 10^{-6}$	$1.000 \times 10^{-12}$	120	$1.000 \times 10^6$	$1.000 \times 10^{12}$	
$3.162 \times 10^{-7}$	$1.000 \times 10^{-13}$	130	$3.162 \times 10^6$	$1.000 \times 10^{13}$	
$1.000 \times 10^{-7}$	$1.000 \times 10^{-14}$	140	$1.000 \times 10^7$	$1.000 \times 10^{14}$	

# Technical description

## 3.1 INTRODUCTION

The following description should be read in conjunction with the block diagram, Fig. 3.1, and the circuit diagrams, Chap. 7.

The circuit is summarized in Sect. 3.2 and then each unit is described in Sect. 3.3 to Sect. 3.16.

## 3.2 CIRCUIT SUMMARY

The signal to the RF IN socket is fed to a mixer (Unit A1 - see Sect. 3.3) where it is heterodyned with the output from a local oscillator. The local oscillator is an accessory crystal oscillator (TK 2302 - see Sect. 3.16), internal oscillator (Units A2, A2a and A2b - see Sect. 3.4) or external oscillator connected to the EXT OSCILLATOR socket, according to the setting of the OSCILLATOR switch (Unit A15).

The output from the mixer is fed to an i.f. amplifier (Unit A3 - see Sect. 3.5) which has a linear phase/frequency response to f.m. The i.f. signal is fed to the IF OUT socket and to a limiter (Unit A4 - see Sect. 3.6) for f.m. or a detector (Unit A11 - see Sect. 3.13) for a.m. according to the setting of the FUNCTION switch. The signal to the a.m. detector is fed through a variable resistor R1, the SET AM level control.

The limiter is followed by a discriminator (Unit A5 - see Sect. 3.7). Alternatively, the output from a calibrator (Unit A12 - see Sect. 3.14) is fed to the discriminator when the FUNCTION switch is at SET CAL. The output from the discriminator is fed through a 200 kHz low-pass filter (Unit A6 - see Sect. 3.8), an i.f. amplifier (Unit A7 - see Sect. 3.9) and, when the FREQUENCY RESPONSE and FUNCTION switches are set accordingly, a 15 kHz low-pass filter (Unit A8 - see Sect. 3.10).

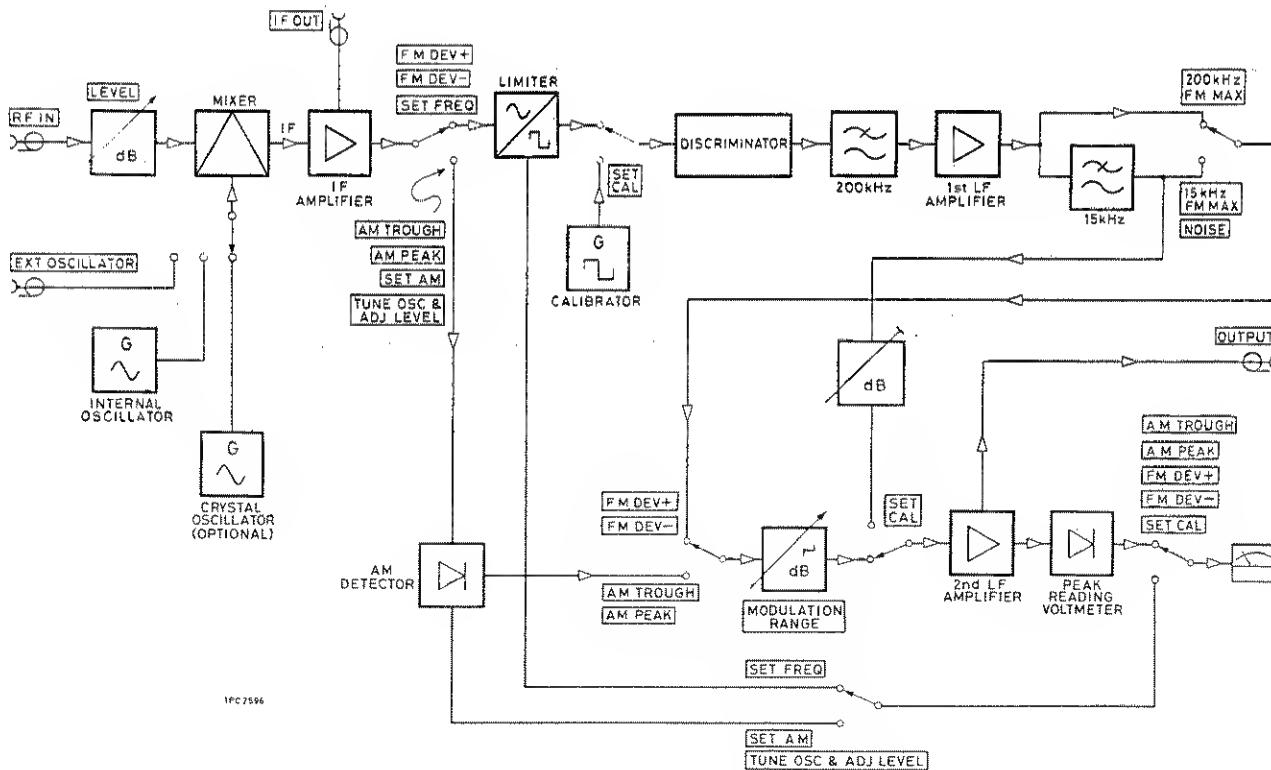


Fig. 3.1 Block diagram

According to the setting of the FUNCTION switch, the 15 kHz low-pass filter (or the 1st l. f. amplifier) for f. m. or the detector for a. m. is connected to an attenuator on the MODULATION RANGE switch SC (on Unit A0). The attenuator consists of one 10 dB and two 20 dB  $\Pi$  sections which are switched in as appropriate. The second 20 dB section contains two preset resistors R2 and R4 for adjusting the deviation reading on the 150 and 500 kHz ranges. When the FUNCTION switch is at SET CAL, the range attenuator is replaced by a  $\Pi$  network containing a preset resistor R3 (on Unit A0) for adjusting the level from the calibrator.

The range attenuator is connected to the previous stage through a capacitor C14 on the FREQUENCY RESPONSE switch SE. C14 gives a 50 Hz high-pass response on the NOISE setting.

After the range attenuator is another l. f. amplifier (Unit A9 - see Sect. 3.11) followed by a peak reading voltmeter (Unit A10 - see Sect. 3.12). When the MODULATION RANGE switch is set to 1.5 kHz, the output to the peak reading voltmeter is from the final stage of the l. f. amplifier. For other settings, the output is from the first stage.

Connected across the output of the first stage of the 2nd l. f. amplifier are three capacitors C5, C6 and C12 on the DE-EMPHASIS switch SD, giving the appropriate low-pass characteristic. Also connected across the output of the first stage is a capacitor C13 on the FREQUENCY RESPONSE switch SE. C13 gives a 15 kHz low-pass response on the NOISE setting.

### 3.3 MIXER—UNIT A1

(Circuit diagram: Fig. 7.2)

The mixer is a conventional, untuned, square law type using a point contact silicon diode MR1. The output is at an i. f. of 1.5 MHz.

The mixer is preceded by an r. f. attenuator AT1, the RF LEVEL control, which gives 6 to 65 dB attenuation at an input impedance of  $50 \Omega$ .

### 3.4 LOCAL OSCILLATOR—UNITS A2, A2a, AND A2b

(Circuit diagram: Fig. 7.2)

There are four oscillator circuits having coverages of  $\sqrt{3}:1$  with frequencies of 5.5 to 9.5, 9.5 to 16.5, 49.5 to 85.5 and 85.5 to 148.5 MHz. The eleven ranges are covered by using harmonics as shown in Table 3.1. The last four ranges are covered by using less than the  $\sqrt{3}:1$  ratio.

The oscillator circuits each consist of a single f. e. t. TR1, TR2, TR3 or TR4 (on Unit A2a) tuned by means of a coil L1, L2, L3 or L4 and several varactor diodes in parallel. The voltage to the varactors is determined by the coarse TUNE FREQUENCY control R1 (on Unit A2), the fine TUNE FREQUENCY control R6 (on Unit A0) and the preset controls R1 to R16 (on Unit A2b). R1 to R16 are for trimming the oscillator ranges to fit the tuning dial. Power is supplied to the required oscillator circuit according to the setting of the FREQUENCY RANGE switch SA (on Unit A2).

The oscillator circuits are followed by a buffer amplifier (on Unit A2a) which consists of a single transistor TR5. Distortion is introduced deliberately to provide good harmonic outputs.

There is a diode D1, D2, D3 or D4 between each oscillator circuit and the buffer amplifier. When the power is on, the diode is forward biased and the signal is allowed to pass through.

TABLE 3.1  
Frequency coverage of internal oscillator

Carrier frequency (MHz)	Oscillator	Harmonic	Oscillator frequency (MHz)
4-8	TR1	1st	5.5-9.5
8-15	TR2	1st	9.5-16.5
15-27	TR1	3rd	16.5-28.5
27-48	TR2	3rd	28.5-49.5
48-84	TR3	1st	49.5-85.5
84-147	TR4	1st	85.5-148.5
147-255	TR3	3rd	148.5-256.5
255-426	TR4	3rd	256.5-427.5
426-650	TR4	5th	427.5-651.5
650-1038	TR4	7th	651.5-1039.5
1038-1200	TR4	8th	1039.5-1201.5

### 3.5 IF AMPLIFIER—UNIT A3

(Circuit diagram: Fig. 7.2)

The i. f. amplifier consists of three stages, each of two transistors, the stages being coupled by band-pass filters. No limiting occurs in the amplifier. Linearity, frequency response and an overall gain of 50 dB are stabilized by negative feedback in each stage.

### 3.6 LIMITER—UNIT A4

(Circuit diagram: Fig. 7.3)

The limiter consists of three stages, each of two emitter-coupled transistors, arranged so that signal amplitudes above a certain level are limited. The emitters are connected to preset resistors to equalize the excursion in each direction.

Part of the i. f. signal is tapped off from the third stage to a differentiating capacitor  $C_7$  and inductor  $L_1$  and then to a detector  $MR_1$  to produce uni-directional pulses as shown in Fig. 3.2. The mean d. c. component  $V_m$  is almost proportional to the repetition frequency. When the FUNCTION switch is set to SET FREQ, this d. c. is fed to the meter which reads SET when the i. f. is correct.

### 3.7 DISCRIMINATOR—UNIT A5

(Circuit diagram: Fig. 7.3)

The first stage of the pulse counter type discriminator is a trigger amplifier  $VT_1$  which precedes a Schmitt trigger  $VT_2$  and  $VT_3$ . This produces a large square wave output with constant rise and fall times. The collector voltage of  $VT_1$  is set by means of a preset resistor  $RV_1$  so that the Schmitt trigger is close to the point of regeneration.

The square wave is fed to a differentiating capacitor  $C_4$  and then to a pulse generator  $VT_4$  and  $VT_5$ . This produces positive-going pulses which are clipped by the next transistor  $VT_6$ . The emitter of  $VT_6$  is taken to the  $-12V$  line so that it clips the bases of the positive-going pulses, thus maintaining constant amplitude.

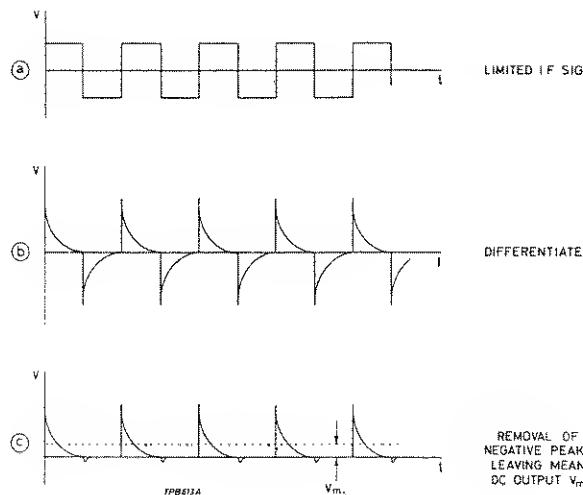


Fig. 3.2 Operation of limiter

A pulse of fixed amplitude and width is generated every time the i. f. signal passes through zero in the positive-going sense as shown in Fig. 3.3. At any given repetition frequency, these pulses have a constant mean amplitude  $V_m$ . Therefore  $V_m$  will vary directly as the deviation.

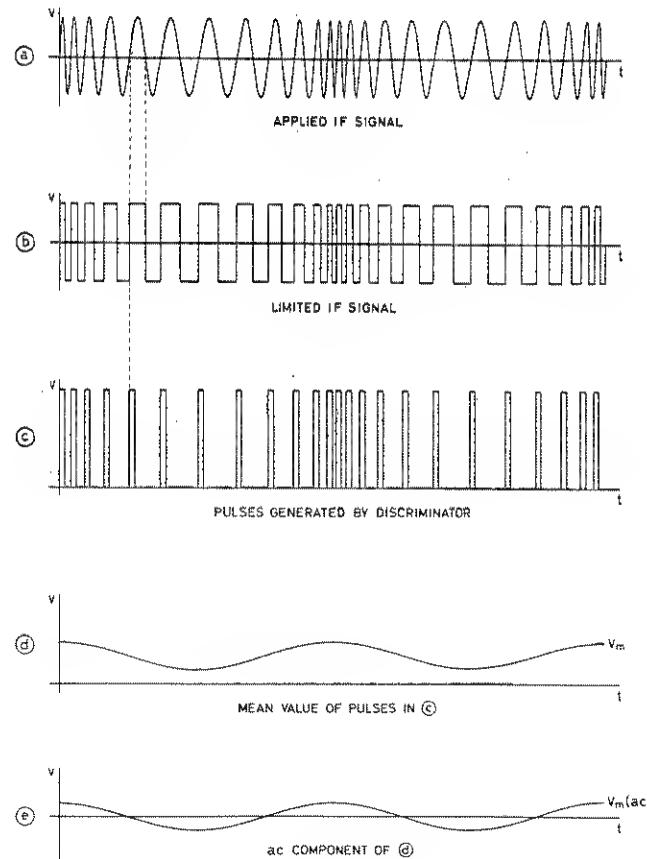


Fig. 3.3 FM demodulation

The output stage is an emitter follower VT7 which, unlike VT6, is conducting continuously and presents a constant low impedance to the following 200 kHz low-pass filter.

### 3.8 200 kHz LOW-PASS FILTER—UNIT A6

(Circuit diagram: Fig. 7.3)

This filter has a response 3 dB down at 250 kHz to give optimum flatness up to 200 kHz. The filter integrates the pulses from the discriminator, as shown in Fig. 3.3 and rejects the i. f. signal. This produces a voltage which is proportional in amplitude to the deviation.

In order to accommodate the channel separation requirements of stereo broadcast monitoring, the filter design is such as to provide a linear phase frequency response over the appropriate part of the frequency range.

### 3.9 1st LF AMPLIFIER—UNIT A7

(Circuit diagram: Fig. 7.3)

The amplifier has high stability, wide bandwidth and constant gain. It consists of a current feedback pair VT1 and VT2 followed by a composite emitter follower VT3 and VT4 which has a very low output impedance. Increased gain is provided by positive feedback through a capacitor C6. DC bias is taken to the first stage through a resistor R8. AC negative feedback is taken to the first stage through R8 and also through a capacitor C5, a resistor R7 and a preset resistor R5 (on Unit A0). R5 is the SET CAL FM preset by which the gain is adjusted. Initially, the gain is adjusted so that a known input deviation gives the correct reading. Whenever necessary, the gain is re-adjusted using the calibrator when the FUNCTION switch is set to SET CAL.

The output impedance is due almost entirely to a resistor R14 which matches the 15 kHz low-pass filter. The input impedance is due almost entirely to a resistor R2 which matches the 200 kHz low-pass filter.

### 3.10 15 kHz LOW-PASS FILTER—UNIT A8

(Circuit diagram: Fig. 7.3)

This filter has a response 3 dB down at 28 kHz to give optimum flatness up to 15 kHz. The filter restricts the bandwidth to the audio range.

When the FUNCTION switch is set to DEV+ or DEV-, the filter is in circuit when the FREQUENCY RESPONSE switch is set to 15 kHz FM MAX or to NOISE. The filter is by-passed by a resistor R26 (on Unit A0) when the FREQUENCY RESPONSE switch is set to 200 kHz FM MAX. The filter is also in circuit when the FUNCTION switch is set to SET CAL in order to prevent high frequency ringing due to the use of a square wave for calibration.

### 3.11 2nd LF AMPLIFIER—UNIT A9

(Circuit diagram: Fig. 7.4)

This unit is similar to the 1st l. f. amplifier, also having high stability, wide bandwidth, constant gain and immunity from supply changes.

The first stage is a current feedback pair VT1 and VT2. Increased gain is provided by positive feedback through a capacitor C6. DC bias is taken to VT1 through a resistor R7. AC negative feedback is taken to VT1 through R7 and also through a capacitor C4, a resistor R8 and a preset resistor RV1 for adjusting the gain. When the MODULATION RANGE switch is set to other than 1.5 kHz, the output for the meter is taken from this stage.

The second stage is another current feedback pair VT3 and VT4. Increased gain is provided by positive feedback through a capacitor C10. DC bias and a.c. negative feedback is taken to VT3 through a resistor R16.

The final stage is a composite emitter follower VT5 and VT6 which has a very low output impedance. When the MODULATION RANGE switch is set to 1.5 kHz, the output for the meter is taken from this stage. The OUTPUT socket is connected to this stage.

The output impedance is due almost entirely to a resistor R22 which matches the external load. The input impedance is due almost entirely to a resistor R2 which matches the range attenuator.

### 3.12 PEAK READING VOLTmeter—UNIT A10

(Circuit diagram: Fig. 7.4)

The first stage is an amplifier VT1, with negative feedback through a resistor R3, directly coupled to an emitter follower VT2. The output from VT2 is fed through a preset resistor RV1, for adjusting the gain, to a current feedback pair VT3 and VT4. Increased gain is provided by positive feedback through a capacitor C6. DC bias is taken to VT3 through a resistor R12. AC negative feedback is taken to VT3 through R12 and also through a capacitor C14 and a resistor R24.

The output from VT4 is fed to the input of another current feedback pair VT5 and VT6 which have the same circuit as VT3 and VT4 except that negative feedback through a resistor R19 gives unity gain. VT5 and VT6 therefore act as an inverter so that the outputs from VT4 and VT5 are in push-pull.

The push-pull outputs are fed through a rectifier MR1 to a capacitor C8 which charges up to the peak voltage. Across C8 is connected the meter M1 (on Unit A0) in series with a resistor R15. MR1, C8, M1 and R15 are connected as appropriate according to the setting of the FUNCTION switch.

### 3.13 AM DETECTOR—UNIT A11

(Circuit diagram: Fig. 7.5)

The signal from the i.f. amplifier is fed to a common-emitter amplifier VT1 which is directly coupled to a composite emitter follower VT2 and VT3. Feedback is taken from VT2 and VT3 to VT1 through two resistors R7 and R6.

The output from VT3 is fed to a parallel tuned circuit L1 and C4 and to a diode detector MR1. L1 and C4 distort the signal to compensate for the non-linearity of MR1 so that the differences in readings between peak and trough are minimal. MR1 is biased by means of a resistor R14. This bias causes the meter to read below zero for a zero input when the FUNCTION switch is at SET AM.

MR1 operates into a resistive load R10 and R12. The voltage developed across R12 is fed through a further resistor R13 to a 50 kHz low pass filter consisting of two  $\Pi$  networks C6, C7, L2 and C8, C9, L3.

A resistor R11 is connected to MR1 so that, when the FUNCTION switch is set to TUNE OSCILLATOR, the d.c. output component is fed to the meter which reads a maximum when the tuning is correct.

### 3.14 CALIBRATOR—UNIT A12

(Circuit diagram: Fig. 7.5)

The output from a multivibrator VT1 and VT2, running at approximately 4 kHz, is fed through a coupling capacitor C6 and resistor R8 to an emitter follower VT4. The square wave from the multivibrator is therefore differentiated and then the negative spikes are clipped. The positive spikes at exactly equal time intervals are fed to a bistable VT7 and VT8 which produces a 2 kHz (approximately) square wave with a mark to space ratio of exactly 1:1.

A crystal XL1 accurately controls at 400 kHz the frequency of an oscillator VT3.

The 2 kHz square wave from the bistable and the 400 kHz sine wave from the oscillator are fed to a gate VT5 and VT6 so that the output is bursts of 400 kHz at a repetition rate of 2 kHz. This has the same effect on the discriminator as an i.f. having a deviation of  $\pm 200$  kHz except that the mean d.c. component is proportional to 200 kHz instead of to 1.5 MHz.

Power is supplied to the calibrator only when the FUNCTION switch is set to SET CAL.

### 3.15 POWER SUPPLY—UNIT A13

(Circuit diagram: Fig. 7.6)

The mains supply is fed from the supply plug PL1 through an interference suppressor FL1, the SUPPLY switch SA (on Unit A0), the mains fuse FS1 and the mains voltage selector SA to the primary of a transformer T1 with the supply lamp LP1 (on Unit A0) across one of the two windings.

For the -18 V supply, a pair of the secondary windings is connected to a diode bridge D5 to D8 with a reservoir capacitor C15. The rectified supply is fed to a regulator IC3 with a pass power transistor TR4. The voltage is adjusted by means of a preset resistor R3. Ripple is reduced by means of a filter R6 and C6. Extra reference smoothing is provided by a capacitor C3.

For the -12 V supply, the -18 V supply is fed to a further regulator IC4 with a complementary pair pass power transistors TR1 and TR3. The voltage is adjusted by means of a preset resistor R11. Noise is reduced by means of a capacitor C13. Extra reference smoothing is provided by a capacitor C12.

For the +16.5 V supply, a pair of the secondary windings is connected to a diode bridge D1 to D4 with a reservoir capacitor C14. The rectified supply is fed to a regulator IC1 with a pass power transistor TR2. The voltage is adjusted by means of a preset resistor R17. Ripple is reduced by

means of a filter R20 and C9. Extra reference smoothing is provided by a capacitor C3.

### 3.16 CRYSTAL OSCILLATOR—TK 2302

(Circuit diagram: Fig. 7.2)

The oscillator stage is a common-base transistor TR1 with an inductive collector load L1 and positive feedback through a crystal XL1, XL2 or XL3 according to the setting of the CRYSTAL switch. L1 is tuned by four varactor diodes D1 to D4 so that the crystal oscillates at the correct overtone. D1 to D4 are controlled by preset resistors R1, R2 and R3 according to the setting of the CRYSTAL switch.

Following the oscillator stage is a harmonic generator consisting of two common-base transistors TR2 and TR3 operating under class 'C' conditions. This produces a very 'spikey' output containing harmonics up to 1000 MHz.



## 4.1 INTRODUCTION

This section contains information for keeping the equipment in good working order and for checking its overall performance.

**CAUTION** This instrument uses semiconductor devices which, although having inherent long term reliability and mechanical ruggedness, are susceptible to damage by overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as reversal of batteries, prolonged soldering, strong r.f. fields or other forms of radiation, use of insulation testers or accidentally applied short circuits. Even the leakage current from an un-earthed soldering iron could cause trouble. Before shorting or breaking any circuit, refer to the circuit diagrams to establish the effect on bias arrangements of the transistors.

### Screw fasteners

Screw threads used on this instrument are mainly M2, M3 and M4 sizes. These are chromium plated or dyed blue. There are also some BA sizes on the main chassis.

Cruciform headed screws are of the Phillips Pozidriv pattern; to avoid damaging them a Pozidriv screwdriver should be used.

## 4.2 ACCESS AND LAYOUT

The case is in two sections. The top cover and the bottom cover are each secured by four screws in the sides of the instrument.

Figs. 4.1 and 4.2 show the general location of all units above and below the chassis. Components may be identified by markings on the boards and chassis. For replacement of sub-assemblies and components, see Sects. 5.5 and 5.6.

## 4.3 PERFORMANCE CHECKS

The tests in this section may be used as a routine maintenance procedure to verify the main performance parameters of the instrument. All tests can be completed without removing the case, except where some internal readjustment is indicated. Tests may be done at any convenient frequency within the carrier range of the modulation meter provided that this frequency is also within the range of the test equipment items a, b, c, d and g.

Many of the methods in this section are simplified and of restricted range compared with those which would be needed to demonstrate complete compliance with the specification. They should be regarded only as providing a check procedure, for use during routine maintenance, to determine whether repair is needed.

### 4.3.1 Test equipment required

See Table 4.1.

### 4.3.2 RF input and i.f. output

Test equipment : items a, d, e, l and n.

This procedure verifies the sensitivity of the modulation meter and the adjustment of the local oscillator.

### RF input resistance

- (1) Turn the RF LEVEL control mid-way. Connect the multimeter, set for resistance measurement, between the centre pin of the RF IN socket and earth and check that the reading is  $50 \Omega \pm 10 \Omega$ .

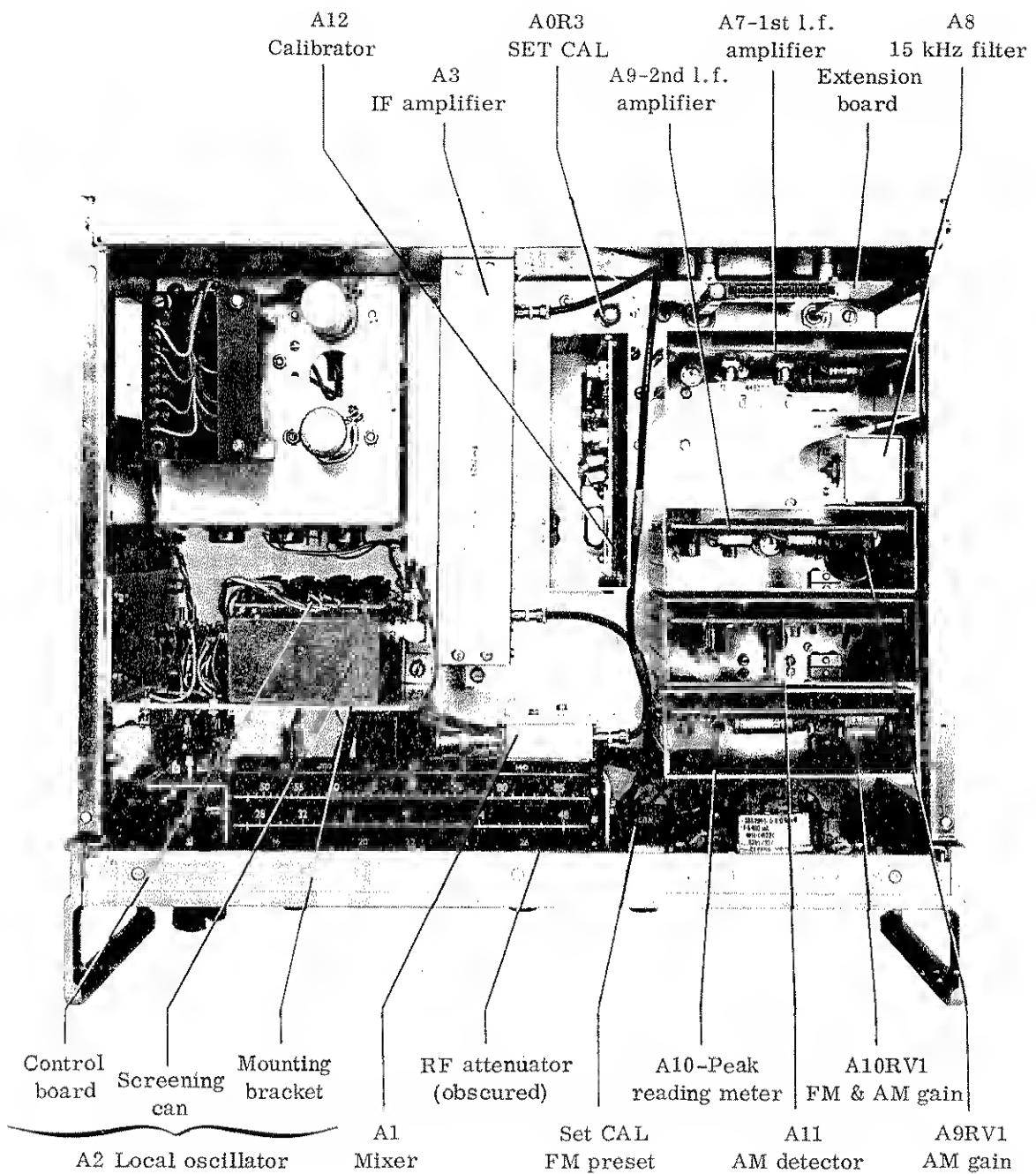


Fig. 4.1 Location of units (top)

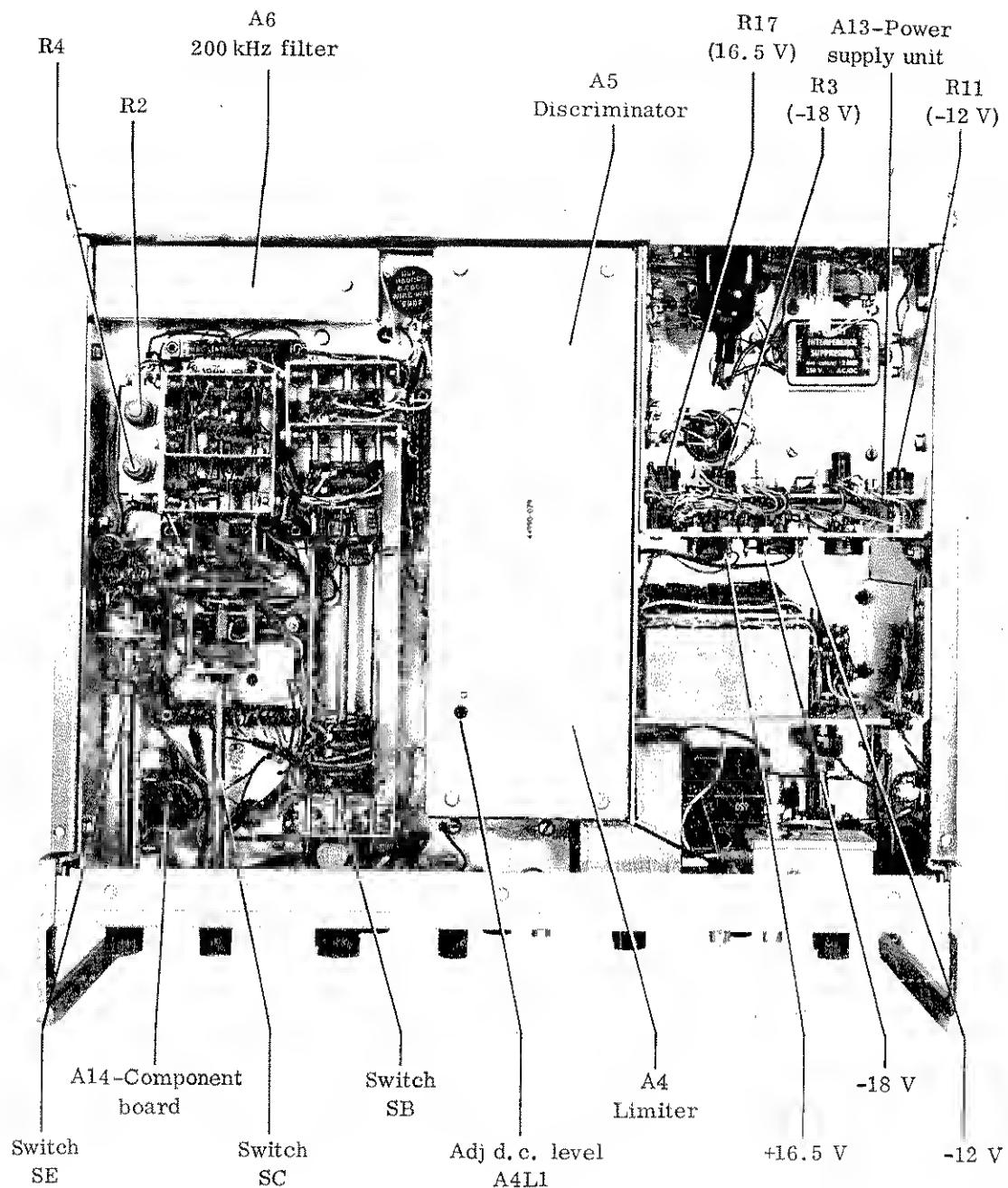


Fig. 4.2 Location of units (bottom)

**RF SENSITIVITY**

(2) Adjust the signal generator to give a c.w. output of about 50 mV p.d. and connect it to the RF IN socket of the modulation meter via the T connector and adapter. Connect the voltmeter probe to the T junction of the connector. See Fig. 5.2.

Note. The T connector/adapter must be connected directly to the TF 2300B RF IN socket for good v.s.w.r. at the input.

(3) On the modulation meter, turn the FREQUENCY RANGE switch and TUNE FRE-

QUENCY controls to suit the r.f. input frequency, the FUNCTION switch to TUNE OSCILLATOR AND ADJUST LEVEL and the RF LEVEL control fully clockwise.

(4) Tune for peak meter deflection and then adjust the signal generator output until the meter deflection is at the bottom of the black arc.

(5) Switch off the TF 2300B and check that the signal generator output, as indicated on the voltmeter, is within the figure given for r.f. input sensitivity in Sect. 1.2 - Data Summary.

**TABLE 4.1**

Item	Type	Minimum specification	Recommended model
a	AM signal generator	Output : 100 mV across 50 $\Omega$ AM : up to 80% Envelope distortion : 1% at 50% mod.	TF 2002 series
b	FM signal generator	Deviation : up to 250 kHz Mod. freq. : up to 150 kHz	TF 995B/2
c	FM signal generator	Output : 200 mV across 50 $\Omega$ Deviation : up to 250 kHz Mod. freq. : up to 150 kHz	TF 1066B/6
d	Electronic voltmeter	Sensitivity : 10 mV r.m.s. or average reading dB calibration	TF 2603
e	Frequenoy meter	Frequency : 580 Hz to 1.5 MHz	TF 2401 series
f	LF oscillator	Frequency : 580 Hz to 56 kHz	TF 1101 (quantity 2)
g	Spectrum analyser	Resolution : 60 dB at 50 Hz	OA 1094 series or TF 2370
h	Oscilloscope	LF general purpose	-
i	Selective level meter	Frequency : 1.4 to 1.6 MHz	OA 2350 series
j	Crystal oscillator	Same frequency and output as item b in test 4.3.5	-
k	Sensitive voltmeter	Frequency : 50 Hz to 15 kHz Sensitivity : 1 mV f.s.d.	TF 2600
l	Multimeter	To measure resistance, 40 to 60 $\Omega$	Salford Selectest
m	Amplitude modulator	AM depth : 80%	TF 1102 or TK 2181
n	T connector	(With very short BNC to N adapter)	TM 7948

## IF output and frequency

(6) Connect the frequency meter to the IF OUT socket and check that the i.f. remains within 10% of 1.5 MHz when the modulation depth of the input signal is varied from 0 to 80%. (Keep the leads as short as possible.) If the frequency is in error see Sect. 5.4.10.

## IF output impedance

(7) Adjust the RF LEVEL control to increase the voltage at the IF OUT socket to 700 mV. Connect a  $10 \text{ k}\Omega \pm 2\%$  resistor across the voltmeter input and check that the reading drops to between 310 and 400 mV.

(1) Connect the signal generator, externally modulated by the l.f. oscillator, to the inputs of the modulation meter and the spectrum analyser, as shown in Fig. 4.3.

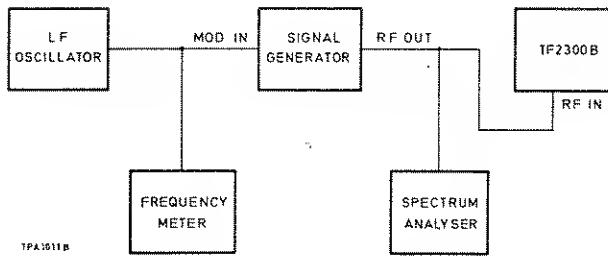


Fig. 4.3 Bessel zero measurement

### 4.3.3 FM deviation accuracy

Test equipment : items b, e, f and g.

If a complete calibration is to be made, first verify that A10RV1 FM and AM GAIN, is at the approximate centre of its travel. In other cases, the setting need not be disturbed if the required adjustments can be made satisfactorily.

The internal f.m. calibrator provides a standard of good long-term stability for checking and resetting the deviation reading accuracy as described in Section 2.5 (8). The calibrator accuracy is largely dependent on the frequency of its 400 kHz oscillator crystal, which is unlikely to change significantly. If the calibrator accuracy is suspected, the deviation reading should be checked by making a normal measurement on a symmetrically modulated signal of accurately known deviation set up by the Bessel Zero method described below.

TABLE 4.2

MODULATION RANGE (kHz)	FREQUENCY RESPONSE (kHz)	Deviation (kHz)	Modulating frequency (kHz)	Carrier disappearance
500	200	480	55.46	3
	200	360.7	150	1
	200	145	26.27	2
150	200	145	26.27	2
	15	48	8.696	2
50	15	48	8.696	2
	15	14.5	2.627	2
15	15	14.5	2.627	2
	15	4.8	0.8696	2
5	15	4.8	0.8696	2
1.5	15	1.4	0.5822	1

(4) If the modulation meter reading differs from 145 kHz when switched to either DEV+ or DEV-, adjust the SET CAL FM preset to give the best compromise accuracy between the two measurements. Then turn the FUNCTION switch to SET CAL and, without disturbing the SET CAL FM preset, bring the meter reading to the SET mark by adjusting the internal f.m. preset, A0R3 - see Fig. 4.1. If this has insufficient range select a new value for resistor A0R19.

(5) This check can also be made at other deviations as shown in Table 4.2.

(6) If the deviation errors show a general trend in one direction the presets A0R3, A0R4, A0R2 and A14RV1 should be adjusted to give the best compromise on their respective ranges. As A0R3 affects all ranges it should be adjusted first.

Preset	Adjust for best compromise on deviation range (kHz)
A0R3	5, 15, 50
A0R4	500
A0R2	150
A14RV1	1.5

(A0R3 will be usually found to give the best compromise by adjusting on the 5 kHz deviation range.)

#### 4.3.4 AM depth accuracy

Test equipment : items a, f and i.

AM depth accuracy, unlike f.m. deviation, cannot be checked against an internal calibrating circuit. Therefore, the a.m. measurement accuracy can only be checked by making a normal measurement on a signal of accurately known modulation depth. A depth of about 50% is recommended. It is important that this signal should have a very low envelope distortion as this can cause an apparent error in depth indication.

The modulation depth can be checked by means of a selective level meter as follows :-

(1) Set the l.f. oscillator frequency to 3 kHz and use it to modulate the signal generator to a depth of nominally 50%.

(2) Set up the modulation meter for measuring this signal as described in Sect. 2.6.

(3) Connect the selective level meter to the IF OUT socket of the modulation meter, tune the level meter to the carrier frequency of 1.5 MHz and set its gain to give a 0 dB reference level.

(4) Retune the level meter to one of the 3 kHz sidebands and adjust the l.f. oscillator output to give a level meter reading of 12 dB below the reference level. If the sideband levels are different, adjust for a mean reading of 12 dB. This corresponds to a modulation depth of 50%.

(5) If the modulation meter reading differs from 50% when switched to either PEAK or TROUGH, adjust the internal preset A9RV1 for the best compromise accuracy between the two readings.

Note : Adjustment of A9RV1 may affect the accuracy of the f.m. deviation reading; therefore, after adjusting A9RV1, reset the f.m. calibration as shown in Sect. 2.5 (8) (not by adjusting the internal preset).

(6) This check can also be made at other modulation depths, as shown in the following table, in order to optimize reading errors.

TABLE 4.3

MODULATION RANGE (%)	Modulation depth (%)	Sideband amplitude (dB)
100	90	-6.94
100	80	-7.96
100	70	-9.12
100	60	-10.46
100	50	-12.04
100	40	-14.02
30	30	-16.52
30	20	-20.00
30	10	-26.02

The higher modulation depths are not recommended unless an unusually low envelope distortion can be achieved.

#### 4.3.5 FM noise

Test equipment : items b, h, j and k.

This is measured by comparing the output of the modulation meter when 5 kHz deviation is applied with the output when deviation is zero. To ensure that the latter output is due to the modulation meter alone it is important that the source should be exceptionally free from spurious noise deviation.

- (1) Apply an f.m. input with 5 kHz deviation from the signal generator. Connect the oscilloscope and voltmeter to the OUTPUT socket as shown in Fig. 4.4.

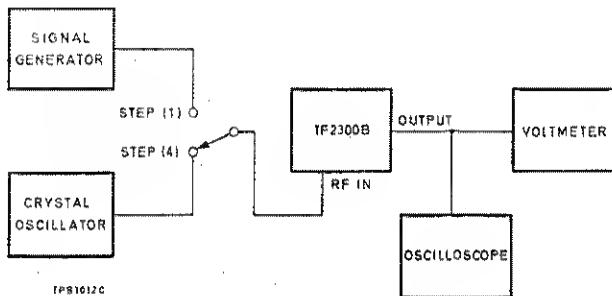


Fig. 4.4 FM noise measurement

- (2) Set the modulation meter for deviation measurement as in Sect. 2.5. Switch the MODULATION RANGE switch to 5 kHz and the FREQUENCY RESPONSE switch to NOISE.
- (3) Note the reading on the voltmeter - this should be about 0 dBm if the modulation meter is terminated in  $600\ \Omega$ .
- (4) Replace the signal generator with the external crystal oscillator set to the same carrier frequency. Increase the voltmeter sensitivity to give a suitable reading and adjust the RF LEVEL control for a minimum reading.

Note the reading on the voltmeter. The difference between this reading and the reading obtained in (3) should be 50 dB or 40 dB depending on the carrier frequency.

- (5) Check that the oscilloscope trace is free from hum, external field and noise. If not, check the power supply ripple - see Sect. 5.4.3.

#### 4.3.6 FM distortion

Test equipment : items b, c, 2f and i.

Because no signal generator is available having f.m. harmonic distortion low enough, the harmonic distortion of the modulation meter cannot be measured directly. It is therefore necessary to measure the intermodulation distortion and then to calculate the equivalent harmonic distortion.

- (1) Set up the equipment as shown in Fig. 4.5. Adjust c to give a c.w. output of 200 mV at a frequency of 200 MHz. Adjust b to give a c.w. output of 50 mV at a frequency of 201.5 MHz, i.e. set to give an i.f. of 1.5 MHz.
- (2) On the modulation meter, set the FUNCTION switch to TUNE and the OSCILLATOR switch to EXT. Adjust the frequency of c for a maximum reading on the meter and adjust the RF LEVEL control for a reading within the black arc.

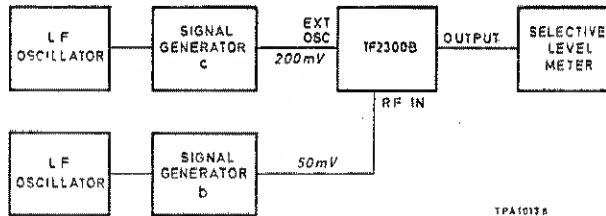


Fig. 4.5 FM distortion measurement

- (3) Switch to FM SET FREQ and adjust c frequency to bring the meter reading to the SET mark.
- (4) Switch to DEV+ and turn the FREQUENCY RESPONSE switch to 15 kHz and the MODULATION RANGE switch to 150 kHz.

generators as shown in the following table, setting up each deviation with the other generator set to c.w.

two levels as shown by the graph. For example, if the two levels are -40 dB and -46 dB, giving a difference of 6 dB, the increment is 1 dB; the sum of the two levels is therefore  $-40 + 1 \text{ dB} = -39 \text{ dB}$ .

Table 4.4

Signal generator	Modulation frequency	Deviation
c	16 kHz (f1)	37.5 kHz (d1)
b	14 kHz (f2)	37.5 kHz (d2)

(6) Switch off b and set up the level meter to give a reference level of -6 dB at f1. Switch on b again.

(7) Measure the levels of the following components :-

2nd order :  $(f_1 - f_2)$  : 2 kHz

3rd order :  $(2f_2 - f_1)$  : 12 kHz

Express the levels in dB relative to 0 dB. Add +6 dB to the 2nd order reading and +9 dB to the 3rd order reading. The r.m.s. sum of the two levels (see below for method of calculation) is equivalent to the harmonic distortion. It should be lower than -54 dB (0.2%).

(8) Repeat the test at two other settings as follows :-

(a) FREQUENCY RESPONSE switch: 200 kHz, f1: 26 kHz, f2: 24 kHz, d1: 150 kHz, d2: 150 kHz. Total deviation: 300 kHz, f1 - f2: 2 kHz, 2f2 - f1: 22 kHz. The distortion should be lower than -50 dB (0.3%).

(b) FREQUENCY RESPONSE switch: 200 kHz, f1: 150 kHz, f2: 140 kHz, d1: 250 kHz, d2: 250 kHz. Total deviation: 500 kHz, f1 - f2: 10 kHz, 2f2 - f1: 130 kHz. The distortion should be lower than -32 dB (2.5%).

### Summation of dB levels

The r.m.s. sum of two dB levels can be obtained by increasing the level of the larger one by an increment between 0 and 3 dB; the value of increment depends on the difference between the

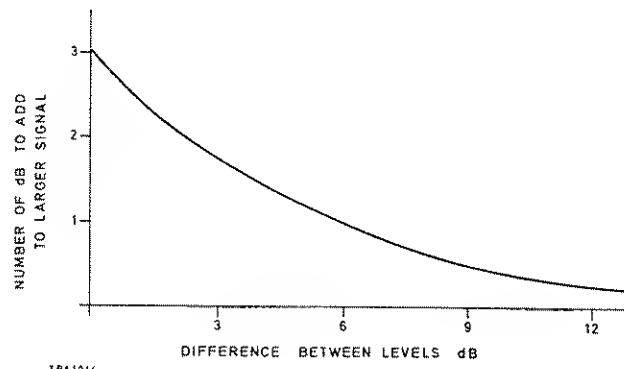


Fig. 4.6 Summation of dB levels

### 4.3.7 AM rejection

Test equipment : items a, f and m.

(1) Set up the equipment as shown in Fig. 4.7. Adjust the signal generator to give a c.w. output of 100 mV at any convenient frequency.

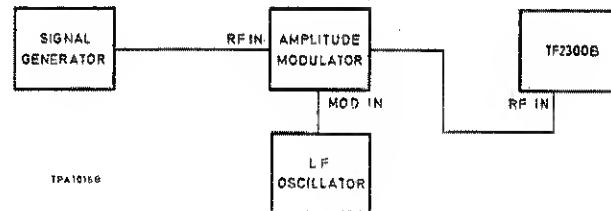


Fig. 4.7 AM rejection measurement

Adjust the l.f. oscillator frequency to 1 kHz at a level which gives 80% modulation on the meter.

(2) Set the FUNCTION switch to TUNE and the TUNE FREQUENCY controls to give a maximum meter reading. Then adjust the RF LEVEL control for a reading within the black arc.

- (3) Switch to FM SET FREQ and adjust the TUNE FREQUENCY controls to bring the meter reading to the SET mark.
- (4) Switch to TUNE and adjust the RF LEVEL control to give a reading just below full-scale on the black arc.
- (5) Turn the MODULATION RANGE switch to 5 kHz and the FREQUENCY RESPONSE switch to 15 kHz.
- (6) Switch to DEV+ and DEV- in turn and check that the residual reading on the meter is less than 500 Hz. It is typically about 150 Hz.

#### 4.4 CLEANING AND LUBRICATING

##### Rotary switch contacts

These should be cleaned once or twice a year, depending on usage, with benzine or white spirit (not carbon tetrachloride). After cleaning wipe the contacts with a suitable lubricant such as a 1% solution of petroleum jelly in white spirit.

##### Oscillator unit

Excessive lubrication must be avoided but the moving parts should be cleaned and lubricated once or twice a year with light machine oil.

## 5.1 INTRODUCTION

This chapter contains information for the localization and repair of faults. Performance limits quoted are for guidance only and should not be taken as guaranteed performance specifications unless they are also quoted in the Data Summary section.

**CAUTION.** See Maintenance, Sect. 4.1, for precautions in handling semiconductors and for advice on screw fasteners.

The extension board is used in servicing printed circuit boards and is released by undoing the two captive thumbscrews found at the left-hand side of the rear panel enabling the board to be lifted out.

In the case of any difficulty, please write to or phone the Marconi Instruments Service Division (see address on back cover) or nearest representative, quoting the type and serial number on the data plate at the rear of the instrument. If the instrument is being returned for repair, please indicate clearly the nature of the fault or the work you require to be done.

## 5.2 FAULT LOCATION

### General procedure

Methodical fault location can be performed at the following three levels :

- (i) Front panel functional checks for general localization of a fault - see Sect. 5.2.2.
- (ii) Internal checks for more detailed localization - see Sect. 5.2.3.
- (iii) Systematic calibration, which can be used to locate a fault for which methods (i) and (ii) are inadequate - see Sect. 5.4.

### 5.2.1 Test equipment required

See Table 5.1.

### 5.2.2 Front panel checks

As a first step in fault finding, the three following tests will help you to verify nearly all the circuits of the modulation meter and to localize the fault to certain areas. These tests can be performed without removing the cover. Failure of all three tests may indicate a faulty power supply, in which case first check the fuse on the rear panel.

- (1) Turn the FUNCTION switch to SET CAL. If the meter reads SET, the calibrator (A12) and the discriminator, 1st and 2nd l.f. amplifier, peak reading voltmeter and associated circuits (A5 to A10) are working. If there is no meter indication, but the 2 kHz calibrator square wave can be seen with an oscilloscope at the OUTPUT socket, then the peak reading voltmeter circuit, (A10), is faulty.

TABLE 5.1

Item	Type	Minimum specification	Recommended model
a	Signal generator	Frequency : 1.5 MHz and between 4 and 1000 MHz. Output : c.w., up to 100 mV.	TF 144, TF 995, TF 1066 or TF 2002 series.
b	Multimeter	20 V d.c. at 20 k $\Omega$ /V. 250 V a.c.	Salford Selectest
c	Measuring oscilloscope	Bandwidth : 5 MHz. Sensitivity : 20 mV/cm.	-

(2) Turn the FUNCTION switch to TUNE OSCILLATOR AND ADJUST LEVEL. Connect a signal to the RF IN socket and check that, by adjusting the TUNE FREQUENCY and RF LEVEL controls, a meter deflection in the black arc can be obtained. If so, the local oscillator, mixer and i.f. amplifier (A1 to A3) and most of the a.m. detector (A11) are working. If not, but the meter deflects when the input frequency is changed to the i.f. of 1.5 MHz, then the local oscillator or mixer are suspect. A fault in the local oscillator can be confirmed if the first paragraph of test 2 gives a positive result when using an external local oscillator.

(3) Turn the FUNCTION switch to FM SET FREQ. or AM SET FREQ. (after setting up the meter deflection as in step 2 above). Check that the meter deflects to the SET mark when the TUNE FREQUENCY control is slightly readjusted. If so, the limiter circuit (A4) is working.

#### Input attenuator

This can be checked by feeding a 1.5 MHz signal into the EXT OSCILLATOR socket. With the OSCILLATOR switch set to EXT and the FUNCTION switch set to TUNE (position 1), the sensitivity should be approximately 150 mV for a meter reading within the black arc.

If an r.f. signal is now applied to the RF IN socket and the RF LEVEL control turned fully clockwise, the sensitivity should be approximately 5 mV for a meter reading within the black arc.

If there is a meter deflection only when the signal is applied to the EXT OSCILLATOR socket, then the mixer or more probably the attenuator is at fault.

#### 5.2.3 Noise

Meter fluctuations, when the instrument is correctly tuned to a c.w. signal and the FUNCTION switch is set to either FM DEV+ or FM DEV-, is indicative of excessive noise.

The checks detailed in Sect. 4.3.5 and 5.4.11 should be carried out to localize the source of the noise. If the check of Sect. 5.4.11 is satisfactory, the noise is most probably due to the local oscillator.

The FREQUENCY RESPONSE switch may be used to determine the frequency content of the noise.

If the noise decreases with the FREQUENCY RESPONSE switch set to NOISE, then the noise is of very low frequency and possibly due to IC1 in the power supply unit A13 (this supplies +16.5 V for the local oscillator).

If the power supply check of Sect. 5.4.3 proves satisfactory, but the local oscillator noise persists on all frequency ranges, then a component on the oscillator control board A2b, or TR5 on board A2a, may be the cause. If the noise occurs on individual frequency ranges, the f.e.t. oscillators TR1 to TR4 on board A2a should be suspected.

#### 5.2.4 Internal checks

Having roughly localized the fault by the front-panel tests it may be more accurately located by signal tracing tests, using the inter-unit wiring diagram as a guide.

(1) First check the power supply unit output voltages at C17 (+16.5 V), C21 (-18 V) and C20 (-12 V) - see Fig. 4.2 for location. If these are incorrect, reset as described in Sect. 5.4.3.

(2) If trouble is suspected between the calibrator unit and the meter, turn the FUNCTION switch to SET CAL and check the calibrator waveforms from the calibrator unit output to the meter. These should be as shown in Sect. 5.3, although the frequency of the square wave modulation is not critical and may differ from the nominal 2 kHz value illustrated.

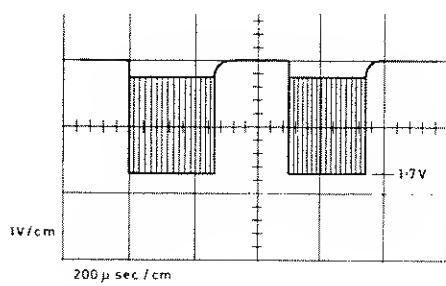
(3) Having identified a faulty board, use the static voltage information on the circuit diagrams as a guide to locating the source of the trouble.

### 5.3 WAVEFORMS

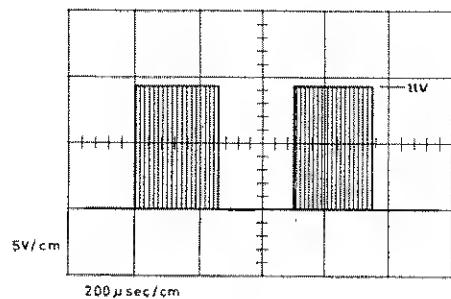
The oscillograms illustrated in Fig. 5.1 show the significant waveforms that occur between the output of the calibrator unit (A12) and the OUTPUT socket. The measuring points are indicated on the inter-unit wiring diagram, Fig. 7.1, and the circuit diagrams.

Measurement should be made with an oscilloscope of at least 5 MHz bandwidth and 20 mV/cm sensitivity. Contact with the printed board edge connectors may be made from below the chassis but, if more convenient, the Extension Board TM 7926 may be used to allow access from above the chassis.

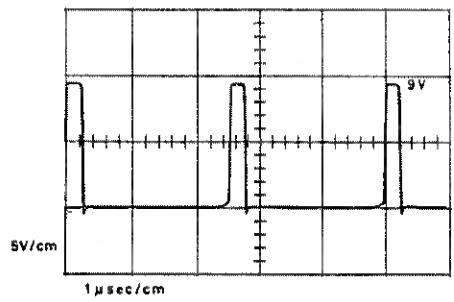
1



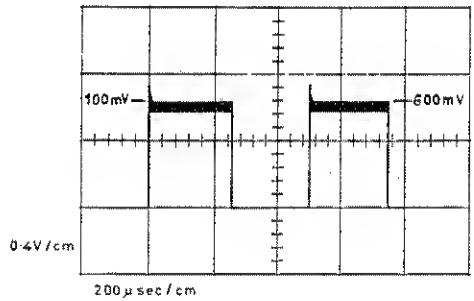
2a



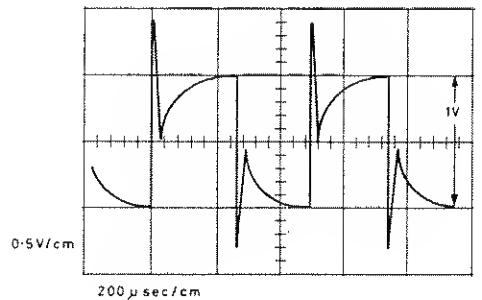
2b



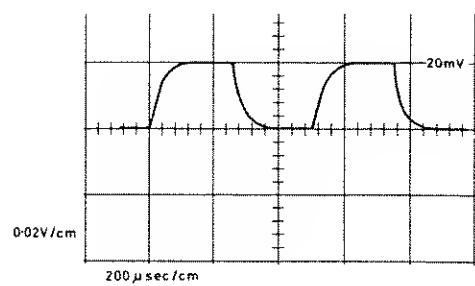
3



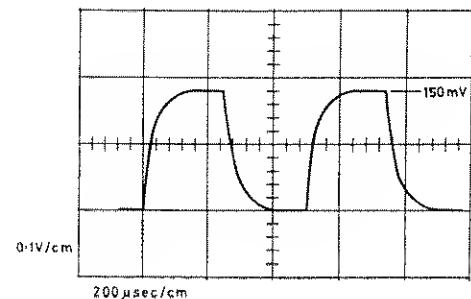
4



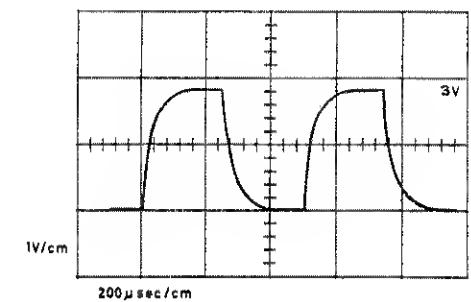
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6



7



8

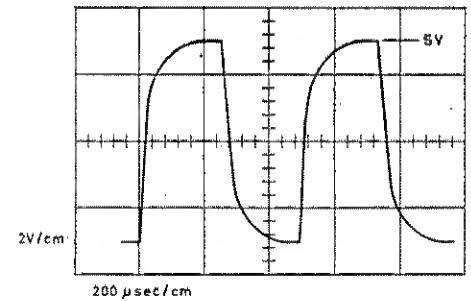


Fig. 5.1 Oscilloscopes

TABLE 5.2

Item	Type	Minimum specification	Recommended model
a	Digital multimeter	Range : 0 - 20 V d.c. 0 - 270 V a.c. Accuracy : $\pm 1\%$ .	TF 2670 or TF 2671
b	Variable mains transformer	Range : 190 - 260 or 90 - 160 V a.c.	Variac
c	Wave analyser	Range : 50 - 200 Hz. Sensitivity : 50 $\mu$ V.	TF 2330A
d	Differential voltmeter	Discrimination: 1 mV in 18 V.	TF 2606
e	Frequency meter	Range : 5 - 150 MHz.	TF 2424A
f	Sweep generator	500 kHz - 27 MHz	TF 2361 with TM 9692
g	Sweep generator	27 - 255 MHz.	TF 2361 with TM 9693
h	Sweep generator	255 - 650 MHz.	TF 2361 with TM 9694
i	Sweep generator	650 - 1200 MHz.	Sanders 6700 with 6722
j	RF millivoltmeter	Range : 4 - 1200 MHz.	TF 2603
k	T connector	(With very short BNC to N adapter)	TM 7948
l	Oscilloscope	Sensitivity : 10 mV/cm.	-
m	Signal source	Range : 100 Hz - 23 kHz.	TF 2001
n	Sensitive voltmeter	Range : 100 Hz - 23 kHz.	TF 2600
o	Crystal oscillator	Frequency : 1.5 MHz.	-
p	RMS voltmeter	Frequency : 30 Hz - 150 kHz. Sensitivity : 1 mV full-scale.	-
q	BNC/miniature Belling adapter		

## 5.4 REALIGNMENT

### 5.4.1 Introduction

This is a complete realignment procedure with the steps arranged in a logical order. If the full procedure is not required, for example following a component replacement, individual steps may be performed providing they do not interact with other adjustments. Although the likelihood of such interaction is pointed out wherever possible, it is recommended that you always consider the effects of any readjustment by reference to the circuit diagrams.

### 5.4.2 Test equipment required - see Table 5.2.

### 5.4.3 Power supply (A13)

Test equipment : items a, b, c and d.

- (1) Measure the output of the regulated supplies at C17, C21 and C20 - see Fig. 4.2. If the voltages are not within  $\pm 1\%$  of nominal, adjust R17 for +16.5 V, R3 for -18 V and R11 for -12 V (see Fig. 4.2).

calibration of the instrument, particularly the frequency scale.

(2) Connect the wave analyser (battery operated) to the +16.5 V line and check that the 50 Hz, 100 Hz and 150 Hz ripple components are each less than 10  $\mu$ V. Check that the same components on the -18 V and the -12 V lines are each less than 10  $\mu$ V.

(3) Replace the wave analyser with the differential voltmeter. Check that the +16.5 V line voltage does not change by more than  $\pm 7$  mV when the a.c. supply is varied from 190 to 260 V, (or 95 to 130 V). The change on the -18 V line should be not greater than  $\pm 20$  mV and on the -12 V line should be not greater than  $\pm 2$  mV.

#### 5.4.4 Local oscillator (A2, A2a and A2b)

Test equipment : item e.

(1) Connect the frequency meter to the oscillator output socket SKJ.

(2) Set the FREQUENCY RANGE switch to range 1 and set the coarse TUNE FREQUENCY control fully counter-clockwise. Check that the pointer lines up with the datum line to the left of the scale. If necessary, adjust the spindle coupling of the TUNE FREQUENCY control.

(3) Set the FREQUENCY RANGE switch to each range in turn and use the coarse TUNE FREQUENCY control to cover each range. With the fine TUNE FREQUENCY control centred and the pointer on the frequency scale at the marks below the scale line, the reading on the counter should be as follows within  $\pm 3\%$  :-

Ranges 1 and 3	5.5 to 9.5 MHz
Ranges 2 and 4	9.5 to 16.5 MHz
Ranges 5 and 7	49.5 to 85.5 MHz
Range 6	85.5 to 148.5 MHz
Range 8	85.5 to 142.5 MHz
Range 9	85.5 to 130.3 MHz
Range 10	93.07 to 148.5 MHz
Range 11	129.94 to 150.19 MHz

(4) If the calibration accuracy is outside limits, adjust the preset resistors on the oscillator control board as follows :-

	Top of range	Bottom of range
1 and 3	R1	R2
2 and 4	R3	R4
5 and 7	R5	R6
6	R7	R8
8	R9	R10
9	R11	R12
10	R13	R14
11	R15	R16

After adjusting one end of a range, recheck the other end and readjust as necessary.

(5) If the preset resistors provide insufficient adjustment, realign the oscillator as described below.

(6) To gain access to the coils, slacken the hexagon-head bolts which hold the oscillator screening box to its mounting bracket, and slide the screening box upwards so that it comes free when the bolts disengage from the keyhole slots in the mounting bracket. There are two further keyhole slots. Insert the lower two bolts in these to hold the screening box in a convenient position.

(7) Set the fine TUNE FREQUENCY control to mid-position and set the preset resistors on the oscillator control board to minimum. After adjusting the preset resistor for one end of a range, recheck the other end and readjust the other preset resistor as necessary.

(8) Set the FREQUENCY RANGE switch to range 1 and set the coarse TUNE FREQUENCY control fully counter-clockwise. Check that the pointer is at the datum line. If necessary, adjust the control coupling. Set the coarse TUNE FREQUENCY control fully clockwise. Adjust L1 to give 9.8 MHz or the nearest frequency obtainable. Set the pointer to the 8 MHz marker and adjust R1 to give 9.5 MHz. Set the pointer to the 4 MHz marker and adjust R2 to give 5.5 MHz.

(9) Set the FREQUENCY RANGE switch to range 2 and set the coarse TUNE FREQUENCY control fully clockwise. Adjust L2 to give 17.0 MHz or the nearest frequency obtainable. Set the pointer to the 15 MHz marker and adjust R3 to give 16.5 MHz. Set the pointer to the 8 MHz marker and adjust R4 to give 9.5 MHz.

(10) Set the FREQUENCY RANGE switch to range 3. Set the pointer to the 27 MHz marker. The counter should read 9.5 MHz. Set the pointer to the 15 MHz marker and then the counter should read 5.5 MHz.

(11) Set the FREQUENCY RANGE switch to range 4. Set the pointer to the 48 MHz marker. The counter should read 16.5 MHz. Set the pointer to the 27 MHz marker and then the counter should read 9.5 MHz.

(12) Set the FREQUENCY RANGE switch to range 5 and set the coarse TUNE FREQUENCY control fully clockwise. Adjust L3 to give 88.8 MHz or the nearest frequency obtainable. There are two possible positions - use the inner one. Set the pointer to the 84 MHz marker and adjust R5 to give 85.5 MHz. Set the pointer to the 48 MHz marker and adjust R6 to give 49.5 MHz.

(13) Set the FREQUENCY RANGE switch to range 6 and set the coarse TUNE FREQUENCY control fully clockwise. Adjust L4 to give 153.0 MHz or the nearest frequency obtainable. Set the pointer to the 147 MHz marker and adjust R7 to give 148.5 MHz. Set the pointer to the 84 MHz marker and adjust R8 to give 85.5 MHz.

(14) Set the FREQUENCY RANGE switch to range 7. Set the pointer to the 255 MHz marker. The counter should read 85.5 MHz. Set the pointer to the 147 MHz marker and then the counter should read 49.5 MHz.

(15) Set the FREQUENCY RANGE switch to range 8. Set the pointer to the 426 MHz marker and adjust R9 to give 142.5 MHz. Set the pointer to the 255 MHz marker and adjust R10 to give 85.5 MHz.

(16) Set the FREQUENCY RANGE switch to range 9. Set the pointer to the 650 MHz marker and adjust R11 to give 130.3 MHz. Set the pointer to the 426 MHz marker and adjust R12 to give 85.5 MHz.

(17) Set the FREQUENCY RANGE switch to range 10. Set the pointer to the 1038 MHz marker and adjust R13 to give 148.5 MHz. Set the pointer to the 650 MHz marker and adjust R14 to give 93.07 MHz.

(18) Set the FREQUENCY RANGE switch to range 11. Set the pointer to the 1200 MHz marker and adjust R15 to give 150.19 MHz. Set the pointer to the 1038 MHz marker and adjust R16 to give 129.94 MHz.

#### 5.4.5 Minimum sensitivity

Test equipment : items f, g, h, i, j, k and l.

In the first part of this test, a sweep generator is used to sweep over each range with the i.f. output displayed on an oscilloscope. The i.f. response is displayed 1.5 MHz above (and also 1.5 MHz below) the frequency to which the TUNE FREQUENCY controls are set (and also harmonics of that frequency). The height of the display depends on the sensitivity of the modulation meter. When the frequency of minimum sensitivity has thus been determined, the output from the generator is measured by means of an r.f. millivoltmeter.

(1) Insert the T connector in the RF IN socket and connect the appropriate sweep generator and the r.f. millivoltmeter to it (see Fig. 5.2). Connect the oscilloscope to the IF OUT socket. Also connect the X drive from the generator to the horizontal input of the oscilloscope. Set the RF LEVEL control fully clockwise.

(2) Set the sweep generator to sweep the range (plus approximately 2 MHz) and tune the coarse TUNE FREQUENCY control over the range. Note the frequency at which the display height is minimum and reset the coarse TUNE FREQUENCY control to this frequency.

(3) Set the sweep generator to manual sweep and to the same frequency to give a peak reading on the meter.

(4) Set the FUNCTION switch to SET FREQ (AM or FM) and slightly readjust the sweep generator so that the meter reading is at the SET line.

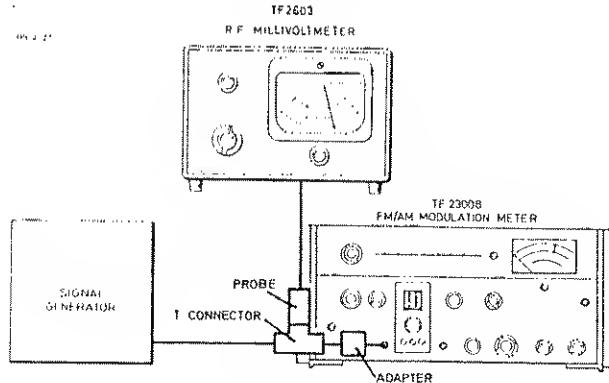


Fig. 5.2 Checking input sensitivity

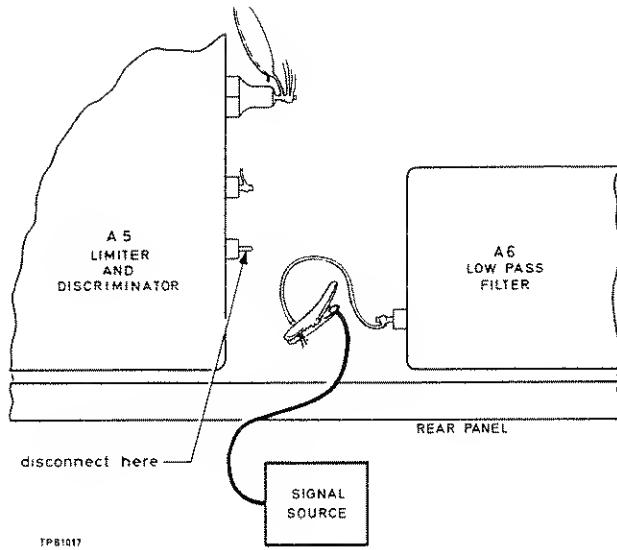


Fig. 5.3 Location of discriminator output lead

(5) Set the FUNCTION switch to TUNE OSCILLATOR and adjust the output level of the sweep generator so that the meter reading is at the lower end of the black arc.

(6) Set the OSCILLATOR switch to EXT (to switch off the internal oscillator) and note the reading on the r.f. millivoltmeter. The reading should be within the figures given for r.f. input sensitivity in Sect. 1.2 - Data Summary.

#### 5.4.6 De-emphasis

Test equipment : items m and n.

(1) With the modulation meter switched off, disconnect the yellow lead from the discriminator unit output (A5, pin 4) and connect the lead to the output of the signal source.

(2) Connect the voltmeter to the OUTPUT socket.

(3) Turn the DE-EMPHASIS switch to 75  $\mu$ s, the FUNCTION switch to DEV+ and the FREQUENCY RESPONSE switch to 200 kHz.

(4) Set the signal source frequency to 100 Hz and adjust its output level to give a suitable reference deflection on the output voltmeter.

(5) Vary the signal source frequency, keeping the output level constant, and check that the response relative to the 100 Hz reference is within  $\pm 1$  dB of :

-3 dB at 2.1 kHz,  
-16.9 dB at 15 kHz.

(6) Repeat step (5) with the DE-EMPHASIS switch set to 50  $\mu$ s and check that the response is within  $\pm 1$  dB of :

-3 dB at 3.15 kHz,  
-16.9 dB at 22.5 kHz.

(7) Repeat step (5) with the DE-EMPHASIS switch set to 750  $\mu$ s and check that the response is as follows :-

Within  $\pm 1$  dB of -3 dB at 210 Hz,  
within  $\pm 2$  dB of -16.9 dB at 1.5 kHz.

#### 5.4.7 Range attenuator

Test equipment : items m and n.

(1) Connect the signal source as in step (1) of Sect. 5.4.6.

(2) Connect the voltmeter to monitor the signal source output.

(3) Turn the MODULATION RANGE switch to 5 kHz and the DE-EMPHASIS switch to OFF.

(4) Set the signal source frequency to 1 kHz and adjust its output to give full-scale deflection on the meter.

(5) Turn the MODULATION RANGE switch to 15 kHz. Increase the signal source output by 10 dB and check that the meter reads within  $\pm 1\%$  of full-scale.

(6) Repeat step (5) for the 50, 150 and 500 kHz deviation ranges. If there is an error on the 150 and 500 kHz ranges, it may be necessary to adjust A0R2 or A0R4 - see Sect. 4.3.3.

(7) Switch off, remove the test equipment and reconnect the yellow lead to the discriminator output.

#### 5.4.8 AM and I.f. response

Test equipment : items m and n.

- (1) On the a.m. detector unit (A11), disconnect the link from pins 17 and 18. Then connect the signal source between pins 18 and 10 (earth).
- (2) Turn the MODULATION RANGE switch to 100% and the FUNCTION switch to AM PEAK.
- (3) Connect one voltmeter across the OUTPUT socket and another to monitor the signal source output.
- (4) Set the signal source frequency to 10 kHz and its output to give a reading of 100% on the modulation meter. Note the reference level on the output voltmeter.
- (5) Vary the signal source frequency, keeping the level constant, between 30 Hz and 50 kHz and note that the reading on the output voltmeter is flat to within  $\pm 0.25$  dB of the reference level.
- (6) Switch off, remove the test equipment and replace the link between A11 pins 17 and 18.

#### 5.4.9 Discriminator trigger

Test equipment : item a.

- (1) With the modulation meter switched off, disconnect the lead from pin 2 on the discriminator unit (A5) and connect the multimeter to the collector of A5VT2 (or VT3).
- (2) Switch on and adjust A5RV1 to a point where the circuit is at change of state, i.e. multimeter either reads 0 V or 15 V. When the potentiometer is adjusted the voltage will jump either to 15 V or 0 V from the original reading. Set to a position just before it jumps.
- (3) Transfer the meter to pin 7 (i.e. test point adjacent to RV1). Note the voltage and decrease it by 0.5 V by rotating RV1 counter-clockwise. Check that the output waveform at the output terminals of the instrument is free from spurious pulses. Switch off and reconnect pin 2.

#### 5.4.10 IF amplifier A3

Test equipment - items f, h, d, o and q

- (1) Replacement of components, other than filter coils, should not normally cause the response of the i.f. amplifier to change, however, if the gain or response require to be checked or the filters are replaced the following procedure should be used :-

Connect the r.f. output of the sweep generator, centred 1.5 MHz, to RF IN. Connect the x drive of the sweep generator to the external x input of the oscilloscope. The oscilloscope y input should be connected via the BNC/miniature Belling adapter to SKTB of the i.f. amplifier. Set the sweep generator output to approximately -15 dBm.

- (2) A typical i.f. amplifier response would have -3 dB points at 1.01 and 1.99 MHz and -20 dB points at 576 kHz and 2.47 MHz.

Adjustment of L4 and L6 tends to move the response about its centre frequency, whilst L2 and L5 both affect the h.f. response.

Adjustment of L1 and L3 aids in control of the skirts of the response curve.

##### (3) Gain

The gain of the i.f. amplifier is approximately 47 dB when measured between SKTA and SKTB of the i.f. amplifier, however, a convenient gain check is between RF IN and SKTB. The expected gain is approximately 32 dB.

With the sweep generator set for zero sweep, i.e. c.w. at a frequency of 1.5 MHz and an output of -15 dBm connected to RF IN, should give an output from SKTB, as measured by the millivoltmeter, of approximately +17 dBm.

##### (4) Set i.f.

Connect the crystal oscillator to the RF IN socket.

Turn the OSCILLATOR switch to EXT and the FUNCTION switch to TUNE.

Set the RF LEVEL control for a meter reading at the top end of the black arc.

Turn the FUNCTION switch to FM SET FREQ and adjust A4L1 through the hole in the limiter/discriminator cover (see Fig. 4.2) to bring the meter reading to the SET mark.

Test equipment : items 1, o and p.

(1) Connect the r.m.s. voltmeter and the oscilloscope to the OUTPUT socket.

(2) Turn the OSCILLATOR switch to EXT.

(3) Connect the 1.5 MHz crystal oscillator to the RF IN socket and turn the FREQUENCY RESPONSE switch to NOISE.

(4) Turn the FUNCTION switch to SET FREQ FM and check that the meter deflects to the SET mark.

(5) Turn the FUNCTION switch to TUNE and adjust the LEVEL control to bring the meter reading to the top end of the black arc.

(6) Turn the FUNCTION switch to SET CAL and adjust the r.m.s. voltmeter range switch to give a convenient reference level. Note this reference level.

(7) Turn the FUNCTION switch to DEV+ and the MODULATION RANGE switch to 5 kHz. Increase the external voltmeter sensitivity and check that the reading is at least 55 dB below the reference level, i.e. -75 dB relative to the level of 50 kHz deviation. If satisfactory, then noise is not due to the discriminator or l.f. circuits but may be due to the oscillator or the power supply.

(8) If not satisfactory, remove the yellow lead from the discriminator output, A5 pin 4 (see Fig. 5.3) and check that the noise level drops to at least -68 dB. A high noise figure can be improved by selection of transistors VT3, VT4, VT5 (most prone to cause noise) and VT6 in the discriminator (A5). The noise display on the oscilloscope should be free of any ripple or hum components, if these are present suspect unit A13, IC3 and IC4 (-18 V and -12 V regulators).

To withdraw the oscillator board, unsolder the seven leads from the feed-through capacitors and the socket and remove the four pillars and the three screws.

### IF amplifier

To remove the lid of the screening box, remove the four screws.

To remove the complete assembly, unsolder the lead from the lead-through terminal, withdraw the two miniature plugs and remove the two screws on the rear panel and the one screw on the chassis.

To remove the board, remove the eight screws, lift up the board and unsolder the lead from the lead-through terminal and the leads from the two sockets.

### Limiter and discriminator

To remove the lid of the screening box, remove the four screws.

To remove the limiter board, unsolder the five leads from the feed-through capacitors, the lead-through terminals and the discriminator board and remove the four nuts.

To remove the discriminator board, unsolder the five leads from the feed-through capacitors and the lead-through terminals and remove the four nuts.

### Printed circuit boards

The following are plug-in circuit boards which can be removed by pressing a spring clip and pulling the board upwards :

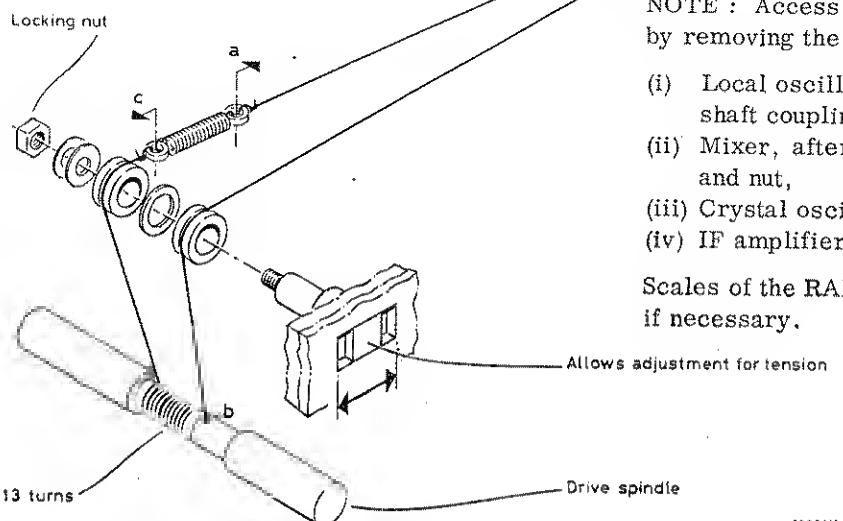
- (1) 1st l.f. amplifier (A7).
- (2) 2nd l.f. amplifier (A9).
- (3) Peak reading voltmeter (A10).
- (4) AM detector (A11).
- (5) Calibrator (A12).

An extension board, type TM 7926, is stowed on the inside of the rear panel. By means of this board, any of the above can be raised above its compartment for examination while in the operative condition.

### Power supply unit

To lift out the power supply board, remove the two screws.

DIMENSIONS OF DRIVE CORD  
 a to b :- 448 mm (17.6 in)  
 a to c :- 700 mm (27.6 in)



NOTE : Access to the drive cord can be improved by removing the following units :

- (i) Local oscillator, after loosening the two shaft couplings,
- (ii) Mixer, after removing the RF LEVEL knob and nut,
- (iii) Crystal oscillator, if fitted,
- (iv) IF amplifier.

Scales of the RANGE switch can also be detached if necessary.

Fig. 5.4 Fitting drive cord

## 5.6 OSCILLATOR DRIVE CORD

Details of the drive cord are shown in Fig. 5.4.

## 5.7 REPLACEMENT OF COMPONENTS

### Fuse

The 20 x 50 mm fuses are fitted in holders which are mounted on the rear panel. Do not change either of these fuses without first switching off the mains supply, otherwise circuit damage could result.

### Transistors

Transistors that are mounted in holders may need to be selected for low noise if replaced.

### Crystal

On the calibrator (Unit A12), the crystal fitted may either have pins to fit a socket or be wire-ended. The socket is always fitted, but with a wire-ended crystal, the socket contacts are removed and taped to the board beneath the crystal. Either type of crystal may be used for replacement, but if a type with pins is to replace a wire-ended type, the socket contacts must be refitted and connected to tags 13 and 14.

### RF attenuator

AT1 is a sealed unit. Contact Marconi Instruments if repair appears necessary in this unit.

# Replaceable parts

## Introduction

The modulation meter consists of a number of sub-assemblies, each of which is allocated an identity number in the sequence A0 to A15 inclusive, as follows :-

- A0 - Main chassis
- A1 - Mixer
- A2 - Oscillator assembly
  - A2a Oscillator
  - A2b Oscillator controls
- A3 - IF amplifier
- A4 - Limiter
- A5 - Discriminator
- A6 - 200 kHz 1.p. filter
- A7 - 1st l.f. amplifier
- A8 - 15 kHz 1.p. filter
- A9 - 2nd l.f. amplifier
- A10 - Peak reading voltmeter
- A11 - AM detector
- A12 - Calibrator
- A13 - Power supply unit assembly
- A14 - Component board
- A15 - Oscillator switch

The complete reference of a part consists of the sub-assembly number followed by its circuit reference, e.g., A4C5, A7R4, etc., and this should always be stated on any order, letter, etc. For convenience in the text and on circuit diagrams, the circuit reference is abbreviated by dropping the sub-assembly prefix except where there is a risk of ambiguity.

Replaceable parts are grouped in order of sub-assembly designation and itemized in alphabetical order of circuit references, with miscellaneous parts at the end of each list. The following abbreviations are used :-

- C : capacitor
- Carb : carbon
- Cer : ceramic
- D : semiconductor diode
- Elec : electrolytic
- FS : fuse
- IC : integrated circuit
- L : inductor
- LP : lamp
- M : meter

Met	: metal
Min	: minimum value
MR	: semiconductor diode
Ox	: oxide
PL	: plug
Plas	: plastic
R	: resistor
RV	: variable resistor
S	: switch
SK	: socket
SKT	: socket
T	: transformer
Tant	: tantalum
TR	: transistor
Var	: variable or preset
VT	: transistor
W	: watts at 70°C
WW	: wirewound
X	: ferrite bead
†	: value selected during test; nominal value listed
Ø	: feed-through component

## Ordering

When ordering replacements, address the order to our Service Division (address on rear cover) or nearest agent and specify the following for each component required.

- (1) Type\* and serial number of instrument
- (2) Complete circuit reference
- (3) Description
- (4) MI code

\* as given on the serial number label at the rear of the instrument; if this is superseded by a model number label, quote the model number instead of the type number.

If a part is not listed, state its function, location and description when ordering.

One or more of the parts fitted to the instrument may differ from those listed in this chapter for any of the following reasons :

- (a) Components indicated by † have their value selected during test to achieve particular performance limits.

			Circuit reference	Description	M.I. code
(b)	Owing to supply difficulties components may be substituted by others of different type or value provided that the overall performance of the instrument is maintained.		R1	Var carb $3.3k\Omega \pm 20\%$ 2W	25645-354
(c)	As part of a policy of continuous development, components may be changed in value or type to obtain detail improvements in performance.		R2	Var WW $500\Omega \pm 10\%$ 1W	25815-147
	Whenever there is such a difference between the component fitted and the one listed, always use a replacement the same type and value as found in the instrument.		R3	Var WW $5k\Omega \pm 10\%$ 1W	25815-129
			R4	Var WW $500\Omega \pm 10\%$ 1W	25815-147
			R5	Var carb $4.7k\Omega \pm 20\%$ 2W	25645-384
			R6	Var carb $100k\Omega \pm 20\%$ 2W	25645-441
			R8	Met film $1.925k\Omega \pm 0.1\% \frac{1}{4}W$	24723-332
			R9	Met film $1.423k\Omega \pm 0.1\% \frac{1}{4}W$	24723-333
	Transistor selection		R10	Met film $1.925k\Omega \pm 0.1\% \frac{1}{4}W$	24723-332
	Transistors that are mounted in holders may need to be selected for low noise if replaced.		R11	Met film $1.222k\Omega \pm 0.1\% \frac{1}{4}W$	24723-331
			R12	Met film $4.95k\Omega \pm 0.1\% \frac{1}{4}W$	24723-335
			R13	Met film $1.18k\Omega \pm 0.1\% \frac{1}{4}W$	24723-334
	<b>A0—Main assembly with range attenuator</b>		R14	Met film $1.027k\Omega 0.1\% \frac{1}{4}W$	24723-330
	When ordering, prefix circuit reference with A0		R15	Met film $33.00k\Omega \pm 1\% \frac{1}{4}W$	24637-556
			R16	Met film $1.027k\Omega \pm 0.1\% \frac{1}{4}W$	24723-330
C1	Cer $0.1\mu F \pm 50-25\%$ 30V	26383-031			
C2	Cer $0.1\mu F \pm 50-25\%$ 30V	26383-031			
C3	Cer $0.1\mu F \pm 50-25\%$ 30V	26383-031	R18	Met film $220k\Omega \pm 2\% \frac{1}{4}W$	24773-329
C4	Cer $0.1\mu F \pm 50-25\%$ 30V	26383-031	R19	Met film $220k\Omega \pm 2\% \frac{1}{4}W$	24773-329
C5	Plas $0.201\mu F \pm 1.1\%$ 125V	26518-330			
C6	Plas $0.302\mu F \pm 1.1\%$ 125V	26518-341	R21	Met film $10k\Omega \pm 2\% \frac{1}{4}W$	24773-297
C7	Plas $0.047\mu F \pm 10\%$ 250V	26582-206	R22	Met film $1.222k\Omega \pm 0.1\% \frac{1}{4}W$	24723-331
C8	Cer $0.1\mu F \pm 50-25\%$ 30V	26383-031	R23	Met film $4.95k\Omega \pm 0.1\% \frac{1}{4}W$	24723-335
C9	Plas $0.047\mu F \pm 10\%$ 400V	26555-471	R24	Met film $1.222k\Omega \pm 0.1\% \frac{1}{4}W$	24723-331
C10	Cer $500pF \pm 10\%$ 500V	26364-301			
			R26	Met ox $22\Omega \pm 2\% \frac{1}{2}W$	24573-033
C12	Plas $3.3\mu F \pm 5\%$ 60V	26551-242			
C13	Plas $0.04\mu F \pm 1\%$ 160V	26516-818	SA	SUPPLY switch	23462-258
C14	Plas $1.5\mu F \pm 2\%$ 100V	26511-398	SB	FUNCTION switch	44340-057
LP1	Red neon lamp 110V	23733-154	SC	MODULATION RANGE switch	44340-056
M1	Meter	44559-006	SD	DE-EMPHASIS switch	44340-059
			SE	FREQUENCY RESPONSE switch	44340-060
PLA	Plug, r.f. miniature	23441-014			
PLB	Plug, r.f. miniature	23441-014	SKK	IF OUT socket, $50\Omega$ , BNC	23443-443
PLC	Plug, r.f. miniature	23441-014	SKL	OUTPUT socket, $50\Omega$ , BNC	23443-443

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code	Circuit reference	Description	M.I. code
<b>A1—Mixer 44990-075</b>					
When ordering, prefix circuit reference with A1					
AT1	Attenuator assembly	44429-006	44429-006 26324-822		
C1	Cer 33pF 5% 750V	26324-822			
MR1	Diode HP5082-2800	28349-007			
R1	Met film $2.7\text{k}\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-283	Complete board		
R2	Met film $470\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-265	C1	Plas $0.47\mu\text{F} \pm 10\% 63\text{V}$	26582-410
R3	Met film $56\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-243	C2	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
R4	Met film $10\text{k}\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-297	C3	Elec $100\mu\text{F} +100-20\% 25\text{V}$	26423-243
SKC	Socket, r.f. miniature	23441-044	C4	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
SKD	RF IN socket, $50\Omega$ , BNC	23443-503	C5	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
SKE	Socket, $50\Omega$ , BNC	23443-406	C6	Plas $560\text{pF} \pm 2\% 350\text{V}$	26516-428
<b>A2a—Oscillator 44827-276</b>					
When ordering, prefix circuit reference with A2a					
R1	Met film $2.7\text{k}\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-283	C7	Elec $100\mu\text{F} +100-20\% 25\text{V}$	26423-243
R2	Met film $470\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-265	C8	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
R3	Met film $56\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-243	C9	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
R4	Met film $10\text{k}\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-297	C10	Plas $330\text{pF} \pm 2\% 350\text{V}$	26516-372
SKC	Socket, r.f. miniature	23441-044	C11	Elec $100\mu\text{F} +100-20\% 25\text{V}$	26423-243
SKD	RF IN socket, $50\Omega$ , BNC	23443-503	C12	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
SKE	Socket, $50\Omega$ , BNC	23443-406	C13	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
<b>A2—Oscillator 44990-080</b>					
When ordering, prefix circuit reference with A2					
C24	Cer $0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665	C14	Plas $560\text{pF} \pm 2\% 350\text{V}$	26516-428
C25	Cer $0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665	C15	Elec $100\mu\text{F} +100-20\% 25\text{V}$	26423-243
C26	Cer $0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665	C16	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
C27	Cer $0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665	C17	Cer $0.001\mu\text{F} +80-20\% 500\text{V}$	26383-242
C28	Cer $0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665	C18	Cer $0.001\mu\text{F} +80-20\% 500\text{V}$	26383-242
C29	Cer $0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665	C19	Cer $0.01\mu\text{F} +80-20\% 100\text{V}$	26383-055
C30	Cer $0.1\mu\text{F} +50-20\% 30\text{V}$	26383-031	C20	Elec $22\mu\text{F} +100-20\% 25\text{V}$	26415-805
R1	Var WW $10\text{k}\Omega \pm 5\% 2\text{W}$	25885-151	C21	Cer $0.001\mu\text{F} +80-20\% 500\text{V}$	26383-242
SA	FREQUENCY RANGE switch	44340-058	C22	Elec $100\mu\text{F} +100-20\% 25\text{V}$	26415-813
SKJ	Socket, $50\Omega$ , BNC	23443-461	D1 to D21	BB405B	28381-101V
			D22	1N4148	28336-676

For symbols and abbreviations see introduction to this chapter

<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>	<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>
D23	1N4148	28336-676	TR4	WN428	28459-025
D24	1N4148	28336-676	TR5	BSX 20	28452-197
D25	1N4148	28336-676			

#### A2b—Oscillator Controls 44827-274

L1	Coil assembly	44290-138	When ordering, prefix circuit reference with A2b		
L2	Coil assembly	44290-137		Complete board	44827-274
L3	Coil assembly	44290-136	R1	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
L4	Coil assembly	44290-135	R2	Var carb 2.2k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-074
L5	RF choke 6.8 $\mu$ H	23642-554	R3	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
R1	Met film 4.7k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-289	R4	Var carb 2.2k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-074
R2	Met film 300 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-260	R5	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
R3	Met film 3k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-284	R6	Var carb 2.2k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-074
R4	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297	R7	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
R5	Met film 300 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-260	R8	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
R6	Met film 3k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-284	R9	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-078
R7	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297	R10	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
R8	Met film 300 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-260	R11	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-078
R9	Met film 2.2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-281	R12	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
R10	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297	R13	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
R12	Met film 820 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-271	R14	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-076
			R15	Var carb 10k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-078
R13	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297	R16	Var carb 22k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-080
R14	Met film 3.3k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-285	R17	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297
R15	Met film 4.7k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-289	R18	Carb 1M $\Omega$ $\pm 5\%$ 1/8W	24311-945
R16	Met film 680 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-269			
R17	Met film 2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-280			
R18	Met film 200 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-256			
R19	Met film 33 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-213		Complete board	44648-102
R20	Met film 3.6k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-286	C1	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031
R25	Met film 820 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-271	C2	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031
T1	Oscillator transformer	43541-014	C3	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031
TR1	BF 244B	28459-036	C4	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031
TR2	BF 244B	28459-036	C5	Mica 352pF $\pm 1\%$ 750 V	26258-141
TR3	WN 428	28459-025	C6	Mica 352pF $\pm 1\%$ 750 V	26258-141

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code	Circuit reference	Description	M.I. code	
C7	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	R15	Met film 1.5k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-277	
C8	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	R16	Met ox 560 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-067	
C9	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	R17	Met ox 470 $\Omega$ 2% $\frac{1}{2}$ W	24573-065	
C10	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	R18	Met ox 18k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-103	
C11	Mica 352pF $\pm 1\%$ 750 V	26258-141	R19	Met ox 4.7k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-089	
C12	Mica 352pF $\pm 1\%$ 750 V	26258-141	R20	Met ox 3.3k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-085	
C13	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	R21	Met ox 390 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-063	
C14	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	R22	Met ox 1.2k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-075	
C15	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	R23	Met film 22 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-233	
C16	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	R24	Met film 680 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-269	
C18	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	SKTA	RF miniature	23441-044	
C19	Cer $\emptyset$ 0.001 $\mu$ F min. 350 V	26372-611	SKTB	RF miniature	23441-044	
L1	55.2 $\mu$ H	44257-402	VT1	MPS 3640	28431-766	
L2	55.2 $\mu$ H	44257-402	VT2	MPS 3640	28431-766	
L3	55.2 $\mu$ H	44257-402	VT3	MPS 3640	28431-766	
L4	55.2 $\mu$ H	44257-402	VT4	BCY 72	28433-487	
L5	55.2 $\mu$ H	44257-402	VT5	BCY 72	28433-487	
L6	55.2 $\mu$ H	44257-402	VT6	BCY 72	28433-487	
R1	Met ox 3.9k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-087	<b>A4—Limiter TM 7285</b>			
R2	Met ox 18k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-103	When ordering, prefix circuit reference with A4			
R3	Met ox 820 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-071	(			
R4	Met ox 200 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-056	Complete board			
R5	Met ox 3.9k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-087	C1	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R6	Met film 39 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-239	C2	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R7	Met film 1.5k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-277	C3	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R8	Met ox 560 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-067	C4	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R9	Met ox 470 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-065	C5	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R10	Met ox 2.7k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-083	C6	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R11	Met ox 11k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-098	C7	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R12	Met ox 150 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-053	C8	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R13	Met ox 2.2k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-081	C9	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	
R14	Met film 39 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-239	C10	Cer 0.1 $\mu$ F +50-25% 25 V	26383-031	

For symbols and abbreviations see introduction to this chapter

<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>	<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>
C11	Cer $0.1\mu\text{F} \pm 50-25\% 25\text{ V}$	26383-031	RV1	Var carb $100\Omega \pm 20\% \frac{1}{4}\text{W}$	25611-102
C12	Cer $0.1\mu\text{F} \pm 50-25\% 25\text{ V}$	26383-031	RV2	Var carb $100\Omega \pm 20\% \frac{1}{4}\text{W}$	25611-102
C13	Cer $\emptyset 0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665	RV3	Var carb $100\Omega \pm 20\% \frac{1}{4}\text{W}$	25611-102
C14	Cer $\emptyset 0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665	VT1	BCY72	28433-487
L1	Assembly TM 8073/2	44253-208	VT2	BCY72	28433-487
			VT3	BCY72	28433-487
			VT4	BCY72	28433-487
MR1	AAZ17	28322-157	VT5	BCY72	28433-487
			VT6	BCY72	28433-487
R1	Met film $1k\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-273	X1	Ferrite bead, FX1115	23635-833
R2	Met film $330\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-261	X2	Ferrite bead, FX1115	23635-833
R3	Met film $680\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-269	X3	Ferrite bead, FX1115	23635-833
R4	Met film $470\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-265	X4	Ferrite bead, FX1115	23635-833
R5	Met film $100\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-249	X5	Ferrite bead, FX1115	23635-833
R6	Met film $680\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-269			
R7	Met film $330\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-261			
R8	Met film $1k\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-273	<b>A5—Discriminator 44827-264</b>		
R9	Met film $1k\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-273	When ordering, prefix circuit reference with A5		
R10	Met film $330\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-261	Complete board		44827-264
R11	Met film $470\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-265	C1	Cer $0.1\mu\text{F} +50-25\% 25\text{ V}$	26383-031
R12	Met film $100\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-249	C2	Cer $10\text{pF} \pm 0.5\text{pF} 750\text{ V}$	26324-085
R13	Met film $680\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-269	C3	Cer $10\text{pF} \pm 0.5\text{pF} 750\text{ V}$	26324-085
R14	Met film $330\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-261	C4	Cer $6.8\text{pF} \pm 0.25\text{pF} 750\text{ V}$	26324-706
R15	Met ox $2k\Omega \pm 2\% \frac{1}{2}\text{W}$	24573-080	C5 †	Plas $27\text{pF} \pm 2\text{pF} 350\text{V}$	26516-109
R16	Met film $1k\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-273	C6	Elec $100\mu\text{F} +100-20\% 25\text{ V}$	26415-813
R17	Met film $330\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-261	C7	Cer $0.1\mu\text{F} +50-25\% 25\text{ V}$	26383-031
R18	Met ox $560\Omega \pm 2\% \frac{1}{2}\text{W}$	24573-067	C8	Cer $0.1\mu\text{F} +50-25\% 25\text{ V}$	26383-031
R19	Met ox $470\Omega \pm 2\% \frac{1}{2}\text{W}$	24573-065	C9	Elec $100\mu\text{F} +100-20\% 25\text{ V}$	26415-813
R20	Met film $100\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-249	C10	Cer $0.1\mu\text{F} +50-25\% 25\text{ V}$	26383-031
R21	Met film $180\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-255	C11	Cer $0.1\mu\text{F} +50-25\% 25\text{ V}$	26383-031
R22	Met film $330\Omega \pm 2\% \frac{1}{4}\text{W}$	24773-261			
R23	Met ox $2.2k\Omega \pm 2\% \frac{1}{2}\text{W}$	24573-081	C13	Cer $\emptyset 0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665
R24	Met ox $2.7k\Omega \pm 2\% \frac{1}{2}\text{W}$	24573-083	C14	Cer $\emptyset 0.0047\mu\text{F} +80-20\% 500\text{V}$	26373-665

For symbols and abbreviations see introduction to this chapter

<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>	<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>
MR1	AAZ17	28322-157	<b>A6—200 kHz Low-pass Filter TM 7700</b>		
MR2	AAZ17	28322-157	When ordering, prefix circuit reference with A6	Complete board	44414-081
R1	Met film 1.5k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-277	C1	Plas 720pF $\pm 1\%$ 350V	26516-928
R2	Met film 1.8k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-279	C2	Plas 0.00144 $\mu$ F $\pm 1\%$ 350V	26516-520
R3	Met film 3.3k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-285	C3	Plas 720pF $\pm 1\%$ 350V	26516-928
R4	Met film 33 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-237	L1	Assembly TM 7842	44266-821
R5	Met film 1k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-273	L2	Assembly TM 7842	44266-821
R6	Met film 100 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-249			
R7	Met film 330 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W †	24773-261	R1	Met film 1 k $\Omega$ $\pm 1\%$ $\frac{1}{4}$ W	24637-101
R8	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297			
R9	Met film 22k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-305			
R10	Met ox 5.6k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-091	<b>A7—1st LF Amplifier 44827-265</b>		
R11	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297	When ordering, prefix circuit reference with A7	Complete board	44827-265
R12	Met ox 1k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-073			
R13	Met ox 200 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-056	C1	Elec 470 $\mu$ F +100-20% 25 V	26415-822
R14	Met ox 1k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-073	C2	Elec 100 $\mu$ F +100-20% 25 V	26415-813
R15	Met ox 12k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-099	C3	Cer 15pF $\pm 5\%$ 750 V	26324-795
R16	Met film 33 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-237	C4	Elec 100 $\mu$ F +100-20% 25 V	26415-813
R17	Met film 470 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-265	C5	Elec 100 $\mu$ F +100-20% 25 V	26415-813
R18	Met film 470 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-265	C6	Elec 100 $\mu$ F +100-20% 25 V	26415-813
			C7	Elec 470 $\mu$ F +100-20% 25 V	26415-822
RV1	Var carb 4.7k $\Omega$ $\pm 20\%$ $\frac{1}{4}$ W	25611-122			
			R1	Met film 100 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-249
VT1	BSX20	28452-197	R2	Met film 1k $\Omega$ $\pm 1\%$ $\frac{1}{4}$ W	24637-101
VT2	BSX20	28452-197	R3	Met film 5.6k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-291
VT3	BSX20	28452-197	R4	Met film 2.2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-281
VT4	BC109	28452-777	R5	Met film 4.7k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-289
VT5	BSY27	28452-843	R6	Met film 5.6k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-291
VT6	BC109	28452-777	R7	Met ox 3.3k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-085
VT7	BC109	28452-777	R8	Met ox 20k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-104
			R9	Met film 2.2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-281
X1	Ferrite bead, FX1115	23635-833	R10	Met film 56 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-243
X2	Ferrite bead, FX1115	23635-833	R11	Met film 82 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-247
X3	Ferrite bead, FX1115	23635-833	R12	Met film 22k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-305

For symbols and abbreviations see introduction to this chapter

<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>	<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>
R13	Met film $1k\Omega \pm 2\% \frac{1}{4}W$	24773-273	R4	Met film $2.2k\Omega \pm 2\% \frac{1}{4}W$	24773-281
R14	Met film $1k\Omega \pm 1\% \frac{1}{4}W$	24637-101	R5	Met film $4.7k\Omega \pm 2\% \frac{1}{4}W$	24773-289
			R6	Met film $5.6k\Omega \pm 2\% \frac{1}{4}W$	24773-291
VT1	BCY71	28435-235	R7	Met ox $20k\Omega \pm 2\% \frac{1}{2}W$	24573-104
VT2	BCY71	28435-235	R8	Met ox $10k\Omega \pm 2\% \frac{1}{2}W$	24573-097
VT3	2N1304	28443-528	R9	Met film $2.2k\Omega \pm 2\% \frac{1}{4}W$	24773-281
VT4	2N1304	28443-528	R10	Met film $500\Omega \pm 1\% \frac{1}{4}W$	24636-808
			R11	Met film $500\Omega \pm 1\% \frac{1}{4}W$	24636-808
			R12	Met film $5.6k\Omega \pm 2\% \frac{1}{4}W$	24773-291
<b>A8—15 kHz Low-pass Filter TM 7702</b>			R13	Met film $2.2k\Omega \pm 2\% \frac{1}{4}W$	24773-281
When ordering, prefix circuit reference with A8			R14	Met film $4.7k\Omega \pm 2\% \frac{1}{4}W$	24773-289
	Complete board	44414-082	R15	Met film $5.6k\Omega \pm 2\% \frac{1}{4}W$	24773-291
C1	Plas $0.0067\mu F \pm 1\% 160V$	26516-683	R16	Met ox $20k\Omega \pm 2\% \frac{1}{2}W$	24573-104
C2	Plas $0.0067\mu F \pm 1\% 160V$	26516-683	R17	Met film $2.2k\Omega \pm 2\% \frac{1}{4}W$	24773-281
L1	Assembly TM 7842/1	44271-409	R18	Met film $56\Omega \pm 2\% \frac{1}{4}W$	24773-243
			R19	Met film $82\Omega \pm 2\% \frac{1}{4}W$	24773-247
			R20	Met film $22k\Omega \pm 2\% \frac{1}{4}W$	24773-305
<b>A9—2nd LF Amplifier TM 8806</b>			R21	Met film $1k\Omega \pm 2\% \frac{1}{4}W$	24773-273
When ordering, prefix circuit reference with A9			R22	Met film $600\Omega \pm 1\% \frac{1}{4}W$	24636-802
	Complete board	44642-108			
C1	Elec $470\mu F \pm 100-20\% 25 V$	26415-822	RV1	Var WW $22k\Omega \pm 10\% 1W$	25811-554
C2	Cer $0.1\mu F \pm 50-25\% 30 V$	26383-031	VT1	BCY 72	28433-487
C3	Cer $15pF \pm 5\% 750 V$	26324-795	VT2	BCY 72	28433-487
C4	Elec $100\mu F \pm 100-20\% 25 V$	26415-813	VT3	BCY 72	28433-487
C5	Elec $100\mu F \pm 100-20\% 25 V$	26415-813	VT4	BCY 72	28433-487
C6	Elec $100\mu F \pm 100-20\% 25 V$	26415-813	VT5	2N1304	28443-528
C7	Elec $470\mu F \pm 100-20\% 25 V$	26415-822	VT6	2N1304	28443-528
C8	Cer $15pF \pm 5\% 750 V$	26324-795			
C9	Elec $100\mu F \pm 100-20\% 25 V$	26415-813			
C10	Elec $100\mu F \pm 100-20\% 25 V$	26415-813			
C11	Elec $470\mu F \pm 100-20\% 25 V$	26415-822	<b>A10—Peak Reading Voltmeter TM 8805</b>		
C12	Elec $100\mu F \pm 100-20\% 25 V$	26415-813	When ordering, prefix circuit reference with A10		
				Complete board	44686-603
R1	Met film $47\Omega \pm 2\% \frac{1}{4}W$	24773-241	C1	Elec $100\mu F \pm 100-20\% 25 V$	26415-813
R2	Met film $1k\Omega \pm 1\% \frac{1}{4}W$	24637-101	C2	Cer $0.1\mu F \pm 50-25\% 30 V$	26383-031
R3	Met film $5.6k\Omega \pm 2\% \frac{1}{4}W$	24773-291	C3	Elec $470\mu F \pm 100-20\% 25 V$	26415-822

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code	Circuit reference	Description	M.I. code
C4	Elec 100 $\mu$ F +100-20% 25 V	26415-813	R22	Met film 4.7k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-289
C5	Elec 100 $\mu$ F +100-20% 25 V	26415-813	R23	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297
C6	Elec 100 $\mu$ F +100-20% 25 V	26415-813	R24	Met film 1M $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-145
C7	Elec 100 $\mu$ F +100-20% 25 V	26415-813			
C8	Elec 15 $\mu$ F $\pm 20\%$ 15 V	26485-278	RV1	Var WW 1.5k $\Omega$ $\pm 10\%$ 1W	25811-542
C9	Elec 100 $\mu$ F +100-20% 25 V	26415-813			
C10	Elec 100 $\mu$ F +100-20% 25 V	26415-813	VT1	BCY 72	28433-487
C11	Elec 100 $\mu$ F +100-20% 25 V	26415-813	VT2	BCY 72	28433-487
C12	Elec 100 $\mu$ F +100-20% 25 V	26415-813	VT3	BCY 72	28433-487
C14	Plas 0.01 $\mu$ F $\pm 10\%$ 630 V	26555-463	VT4	2N706	28433-356
C15	Cer 15pF $\pm 0.25$ pF 750 V	26324-712	VT5	2N706	28433-356
			VT6	BCY 72	28433-487
MR1	1N914	28336-676			
R1	Met ox 3.9k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-087	<b>A11—AM Detector 44827-270</b>		
R2	Met film 5.6k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-291	When ordering, prefix circuit reference with A11		
R3	Met ox 15k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-101	Complete board		
R4	Met film 2.7k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-283	C1	Cer 0.1 $\mu$ F +50-25% 30 V	26383-031
R5	Met film 4.7k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-289	C2	Cer 0.1 $\mu$ F +50-25% 30 V	26383-031
R6	Met film 2.2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-281	C3	Cer 0.1 $\mu$ F +50-25% 30 V	26383-031
R7	Met ox 1.2k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-075	C4	Plas 680pF $\pm 2\%$ 350V	26516-446
R8	Met film 10k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-297	C5	Cer 0.1 $\mu$ F +50-25% 30V	26383-031
R9	Met film 2.2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-281	C6	Plas 0.0028 $\mu$ F $\pm 2\%$ 160V	26516-591
R10	Met film 5.6k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-291	C7	Plas 0.0028 $\mu$ F $\pm 2\%$ 160V	26516-591
R11	Met film 4.7k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-289	C8	Plas 0.0028 $\mu$ F $\pm 2\%$ 160V	26516-591
R12	Met ox 20k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-104	C9	Plas 0.0028 $\mu$ F $\pm 2\%$ 160V	26516-591
R13	Met ox 470 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-065			
R14	Met ox 1k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-073	L1	22 $\mu$ H	44290-244
R15	Met ox 68k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-117	L2	3.54mH	44267-403
R16	Met ox 20k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-104	L3	3.54mH	44267-403
R17	Met ox 1k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-073			
R18	Met ox 470 $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-065	MR1	AAZ17	28322-157
R19	Met ox 20k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-104			
R20	Met film 2.2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-281	R1	Met ox 3k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-084
R21	Met film 5.6k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-291	R2	Met ox 910k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-072

For symbols and abbreviations see introduction to this chapter

<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>	<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>
R3	Met ox $1k\Omega \pm 2\% \frac{1}{2}W$	24573-073	MR1	AAZ17	28322-157
R4	Met ox $100\Omega \pm 2\% \frac{1}{2}W$	24573-049	MR2	AAZ17	28322-157
R5	Met ox $8.2k\Omega \pm 2\% \frac{1}{2}W$	24573-095			
R6	Met ox $20k\Omega \pm 2\% \frac{1}{2}W$	24573-104			
R7	Met ox $20k\Omega \pm 2\% \frac{1}{2}W$	24573-104	R1	Met film $4.7k\Omega \pm 2\% \frac{1}{4}W$	24773-289
R8	Met ox $1.5k\Omega \pm 2\% \frac{1}{2}W$	24573-077	R2	Met film $560\Omega \pm 2\% \frac{1}{4}W$	24773-267
R9	Met ox $470\Omega \pm 2\% \frac{1}{2}W$	24573-065	R3	Met film $120k\Omega \pm 2\% \frac{1}{4}W$	24773-323
R10	Met ox $2.4k\Omega \pm 2\% \frac{1}{2}W$	24573-082	R4	Met ox $82k\Omega \pm 2\% \frac{1}{2}W$	24573-119
R11	Met film $12k \pm 1\% \frac{1}{4}W$	24637-513	R5	Met film $560\Omega \pm 2\% \frac{1}{4}W$	24773-267
R12	Met ox $820\Omega \pm 2\% \frac{1}{2}W$	24573-071	R6	Met film $4.7k\Omega \pm 2\% \frac{1}{4}W$	24773-289
R13	Met ox $330\Omega \pm 2\% \frac{1}{2}W$	24573-061	R7	Met film $10k\Omega \pm 2\% \frac{1}{4}W$	24773-297
R14	Met ox $1M\Omega \pm 2\% \frac{1}{2}W$	24573-145	R8	Met film $5.6k\Omega \pm 2\% \frac{1}{4}W$	24773-291
			R9	Met film $1k\Omega \pm 2\% \frac{1}{4}W$	24773-273
VT1	MPS 3640	28431-766	R10	Met film $22k\Omega \pm 2\% \frac{1}{4}W$	24773-305
VT2	MPS 3640	28431-766	R11	Met ox $15k\Omega \pm 2\% \frac{1}{2}W$	24573-101
VT3	2N706	28433-356	R12	Met film $1k\Omega \pm 2\% \frac{1}{4}W$	24773-273
			R13	Met film $15k\Omega \pm 2\% \frac{1}{4}W$	24773-301
			R14	Met film $10k\Omega \pm 2\% \frac{1}{4}W$	24773-297
			R15	Met film $22k\Omega \pm 2\% \frac{1}{4}W$	24773-305
			R16	Met film $10k\Omega \pm 2\% \frac{1}{4}W$	24773-297

#### A12—Calibrator TM 7620

When ordering, prefix circuit reference with A12

Complete board	44687-101				
C1	Cer $33pF \pm 5pF$ 750V	26324-822	R17	Met film $10k\Omega \pm 2\% \frac{1}{4}W$	24773-297
C2	Plas $0.047\mu F \pm 10\%$ 250V	26582-206	R18	Met film $560\Omega \pm 2\% \frac{1}{4}W$	24773-267
C3	Cer $300pF \pm 10\%$ 500V	26364-158	R19	Met film $470\Omega \pm 2\% \frac{1}{4}W$	24773-265
C4	Plas $0.0015\mu F \pm 5\%$ 350V	26516-528	R20	Met film $560\Omega \pm 2\% \frac{1}{4}W$	24773-267
C5	Plas $0.047\mu F \pm 10\%$ 250V	26582-206	R21	Met film $10k\Omega \pm 2\% \frac{1}{4}W$	24773-297
C6	Cer $0.001\mu F \pm 10\%$ 500V	26364-302	R22	Met film $15k\Omega \pm 2\% \frac{1}{4}W$	24773-301
C7	Cer $100pF \pm 2pF$ 63V	26343-477	R23	Met film $10k\Omega \pm 2\% \frac{1}{4}W$	24773-297
C8	Cer $0.001\mu F \pm 10\%$ 500V	26364-302	R24	Met film $10\Omega \pm 2\% \frac{1}{4}W$	24773-225
C9	Cer $0.003\mu F \pm 25\%$ 500V	26364-402			
C10	Cer $0.004\mu F \pm 25\%$ 500V	26364-403	VT1	2S323	28433-318
C11	Elec $100\mu F \pm 100-20\%$ 25V	26417-158	VT2	2S323	28433-318
C12	Cer $0.004\mu F \pm 20\%$ 25V	26364-403	VT3	2N404	44522-004
C13	Cer $0.001\mu F \pm 10\%$ 500V	26364-302	VT4	2N404	44522-004
C14	Elec $100\mu F \pm 100-20\%$ 25V	26417-158	VT5	2N404	44522-004
C15	Cer $0.1\mu F \pm 50-25\%$ 30V	26383-031	VT6	2N404	44522-004

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code	Circuit reference	Description	M.I. code
VT7	2N404	44522-004	FS1	Fuse link 160mA	23411-054
VT8	2N404	44522-004	FS2	(115V operation)	
				Fuse holder	23416-192
XL1	QM27U	28311-690		Fuse holder cover	23416-198
			IC1	μA 723	28461-706
			IC3	μA 723	28461-706
			IC4	μA 723	28461-706
<b>A13—Power Supply Unit 44990-308</b>					
When ordering, prefix circuit reference with A13					
	Complete board	44827-275			
C1	Elec 220μF ±100-20% 10V	26423-251	PL1	Mains/filter connector	23423-150
C3	Elec 220μF ±100-20% 10V	26423-251			
C4	Plas 510pF ±2% 350V	26516-417	R2	Met film 12kΩ ±2% 1/4W	24773-299
C5	Elec 100μF ±100-20% 25V	26423-243	R3	Var WW 2.2kΩ ±10% 1W	25811-021
C6	Elec 100μF ±100-20% 40V	26415-814	R4	Met film 3.9kΩ ±2% 1/4W	24773-287
C7	Plas 680pF ±2% 350V	26516-446	R5	Met film 6.2kΩ ±2% 1/4W	24773-292
C8	Plas 510pF ±2% 350V	26516-417	R6	Met film 330Ω ±2% 1/4W	24773-261
C9	Elec 100μF ±100-20% 40V	26415-814	R7	Met ox 1.8Ω ±10% 1/2W	24582-559
C10	Elec 100μF ±100-20% 25V	26423-243	R8	Met film 6.8kΩ ±2% 1/4W	24773-293
C12	Elec 220μF ±100-20% 10V	26423-251	R9	Met film 6.8kΩ ±2% 1/4W	24773-293
C13	Elec 220μF ±100-20% 16V	26423-253	R10	Met film 12kΩ ±2% 1/4W	24773-299
C14	Elec 2200μF ±50-10% 40V	26426-086	R11	Var WW 2.2kΩ ±10% 1W	25811-021
C15	Elec 2200μF ±50-10% 40V	26426-086	R12	Met film 4.7kΩ ±2% 1/4W	24773-289
C16	Plas 0.47μF ±20% 100V	26582-523	R14	Met film 560Ω ±2% 1/4W	24773-267
C17	Cer Ø 4700pF ±80-20% 500V	26373-665	R16	Met film 12kΩ ±2% 1/4W	24773-299
C18	Cer Ø 4700pF ±80-20% 500V	26373-665	R17	Var WW 2.2kΩ ±10% 1W	25811-021
C19	Cer Ø 4700pF ±80-20% 500V	26373-665	R18	Met film 4.7kΩ ±2% 1/4W	24773-289
C20	Cer Ø 4700pF ±80-20% 500V	26373-665	R19	Met film 6.2kΩ ±2% 1/4W	24773-292
C21	Cer Ø 4700pF ±80-20% 500V	26373-665	R20	Met film 330Ω ±2% 1/4W	24773-261
C22	Cer 0.1μF 20% 100V	26386-409	R21	Met ox 10Ω ±2% 1/2W	24573-025
D1	1N4004	28357-028	R22	Met film 12kΩ ±2% 1/4W	24773-299
D8			R23	Met film 12kΩ ±2% 1/4W	24773-299
FS1	Fuse link 100mA (230V operation)	23411-052	SA	Mains voltage selector	23467-161
FS2			T1	Mains transformer	43490-014

For symbols and abbreviations see introduction to this chapter

<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>	<i>Circuit reference</i>	<i>Description</i>	<i>M.I. code</i>
TR1	BCY72	28433-487	C4	Tant 4.7 $\mu$ F $\pm 20\%$ 35 V	26486-556
TR2	2N3055	28456-567	C5	Plas 150pF $\pm 2\%$ 350V	26516-289
TR3	2N3055	28456-567	C6	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
TR4	2N3055	28456-567	C7	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
			C8	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
			C9	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
			C10	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
			C11	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
			C12	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
	Complete board	44688-106	C13	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
C1	Elec 100 $\mu$ F +100-20% 25V	26417-158	C14	Cer 0.001 $\mu$ F +80-20% 500 V	26383-242
R1	Met ox 18k $\Omega$ $\pm 2\%$ $\frac{1}{2}$ W	24573-103	C15	Cer 33pF $\pm 5\%$ 63V	26343-471
RV1	Var WW 5k $\Omega$ $\pm 10\%$ 1W	25811-547	D1	BB105	28381-096
			D2	BB105	28381-096
			D3	BB105	28381-096
			D4	BB105	28381-096
<b>A14—Component Board TM 8742</b>					
<i>When ordering, prefix circuit reference with A14</i>					
	Complete board	44688-106	C13	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055
			C14	Cer 0.001 $\mu$ F +80-20% 500 V	26383-242
			C15	Cer 33pF $\pm 5\%$ 63V	26343-471
			D1	BB105	28381-096
			D2	BB105	28381-096
			D3	BB105	28381-096
			D4	BB105	28381-096
<b>A15—Oscillator Switch 44990-084</b>					
<i>When ordering, prefix circuit reference with A15</i>					
	Complete board	44990-084	L1	Oscillator coil	44290-152
PLE	Plug, 50 $\Omega$ , BNC	23443-307	L2	Harmonic generator coil	44251-207
PLJ	Plug, 50 $\Omega$ , BNC	23443-307	L3	Harmonic generator coil	35124-411
			L4	Harmonic generator coil	44251-207
R1	Met film 510 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-266	L5	Harmonic generator coil	35124-411
SA	OSCILLATOR switch	44340-061	PLA	Plug, 2mm	23421-056
			PLB	Plug, 50 $\Omega$ , GP	23444-027
SKF	Socket, 50 $\Omega$ , BNC	23443-540			
SKG	Socket, 2mm	23421-126			
SKH	Socket, 50 $\Omega$ , GP	23444-146	R1	Var carb 20k $\Omega$ $\pm 20\%$ $\frac{1}{2}$ W	25621-301
			R2	Var carb 20k $\Omega$ $\pm 20\%$ $\frac{1}{2}$ W	25621-301
			R3	Var carb 20k $\Omega$ $\pm 20\%$ $\frac{1}{2}$ W	25621-301
			R4	Met film 1.2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-275
<b>Crystal Oscillator TK 2302</b>					
	Complete board	44827-277	R5	Met. film 1.2k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-295
C1	Cer 0.001 $\mu$ F +80-20% 500 V	26383-242	R6	Met film 1.5k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-277
C2	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055	R7	Met film 47 $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-241
C3	Cer 0.01 $\mu$ F +80-20% 100 V	26383-055	R8 †	Met film 1k $\Omega$ $\pm 2\%$ $\frac{1}{4}$ W	24773-273

*For symbols and abbreviations see introduction to this chapter*

Circuit reference	Description	M.I. code	Circuit reference	Description	M.I. code
R9	Met film $270\Omega \pm 2\% \frac{1}{4}W$	24773-259	Knob, RF LEVEL control		41149-018
R10	Met film $22k\Omega \pm 2\% \frac{1}{4}W$	24773-305	Knob, DE-EMPHASIS switch		41146-011
R11	Met film $100\Omega \pm 2\% \frac{1}{4}W$	24773-249	Knob, OSCILLATOR switch		41146-011
R12	Met film $220\Omega \pm 2\% \frac{1}{4}W$	24773-257	Knob, SET AM control		41149-017
R13 †	Met film $47\Omega \pm 2\% \frac{1}{4}W$	24773-241	Knob, FUNCTION switch		41146-014
R14	Met film $100\Omega \pm 2\% \frac{1}{4}W$	24773-249	Knob, MODULATION RANGE switch		41146-011
R15	Met film $220\Omega \pm 2\% \frac{1}{4}W$	24773-257	Knob, FREQUENCY RESPONSE switch		41146-011
R16 †	Met film $47\Omega \pm 2\% \frac{1}{4}W$	24773-241	Window, TUNING dial		37490-020
R17	Met film $1k\Omega \pm 2\% \frac{1}{4}W$	24773-273	Lower cover (feet and stand not included)		35417-538
R18	Met film $1k\Omega \pm 2\% \frac{1}{4}W$	24773-273	Attachment screw (four)		21838-457
R19	Met film $1k\Omega \pm 2\% \frac{1}{4}W$	24773-273	Washer (four)		21177-650
R20	Met film $390\Omega \pm 2\%$	24773-263	Stand		35116-109
SA	CRYSTAL switch	44340-062	Front foot (two)		37588-111
			Attachment screw		21851-463
TR1	BFY90	28452-157	Rear foot (two)		22315-663
TR2	BSX20	28452-197	Attachment screw		21851-463
TR3	BSX20	28452-197	Nut		21882-110
X1,2,3	Femto lead	23635-833X	Washer		21177-650
			Top cover		35523-419
			Attachment screw (four)		21838-457
			Washer (four)		21177-650
			Locking plate, Mains voltage selector		34444-116
			Attachment screw (two)		21837-357
			Washer (two)		21177-648

For symbols and abbreviations see introduction to this chapter



## Circuit notes

### 1. ARRANGEMENT

The inter-unit wiring diagram, Fig. 7.1, shows all sub-assembly units in the equipment together with their reference designators (A1, A2 etc.) and part numbers. Components that are not on a sub-assembly are part of the main chassis assembly (designated A0).

Circuit diagrams are arranged in order of the sub-assembly designations.

### 2. COMPONENT VALUES

Resistors : No suffix = ohms, k = kilohms, M = megohms.

Capacitors : No suffix = microfarads, p = picofarads.

Inductors : No suffix = henries, m = millihenries,  $\mu$  = microhenries.

† : value selected during test, nominal value shown.

### 3. VOLTAGES

Printed in italics. Voltages are d.c. and relative to chassis unless otherwise indicated. Measured with a 20 k $\Omega$ /V meter.

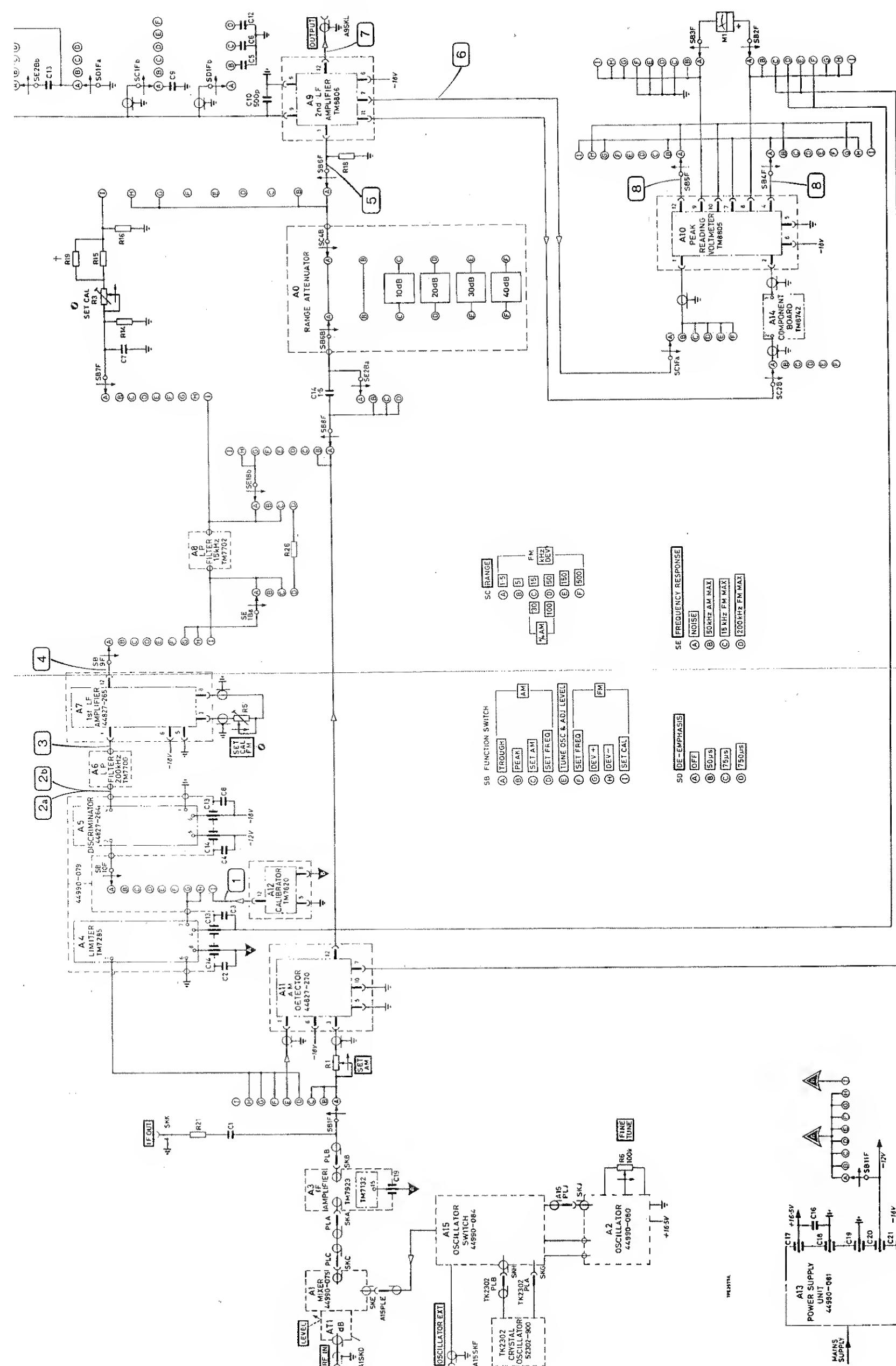
### 4. SYMBOLS

- arrow indicates clockwise rotation of knob.
- preset component.
- [INPUT] panel marking.
- indicates points at same supply potential.
- [2] waveform reference number.

### 5. SWITCHES

Rotary switches are drawn schematically. Letters indicate the control knob setting as shown in the key diagrams. The sequence of sections reading from control knob end is as follows :-

1F = 1st section, front  
1B = 1st section, back  
2F = 2nd section, front  
etc.





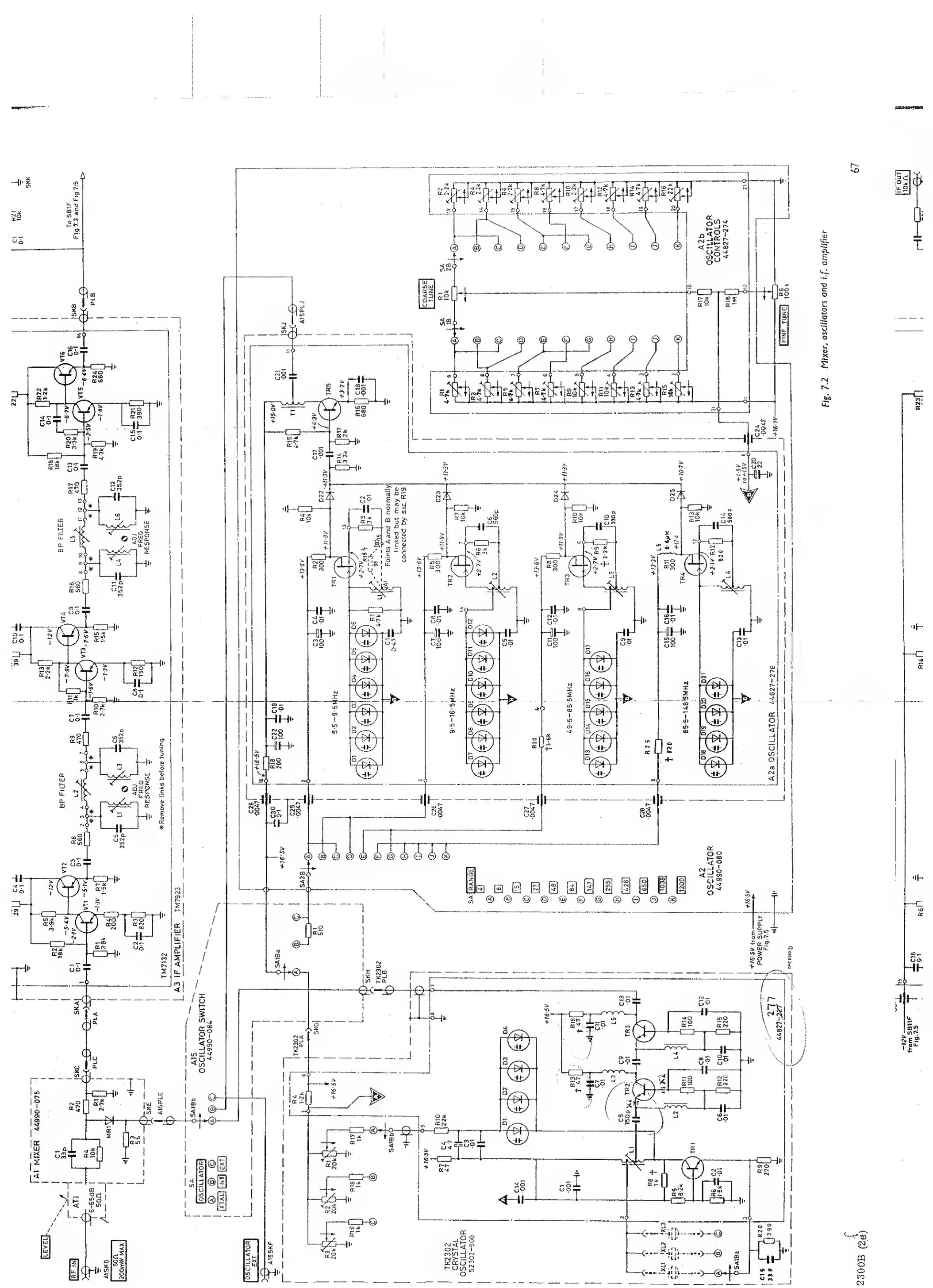


Fig. 7.2 Mixer, oscillators and i-f. amplifier

2300B (2e)



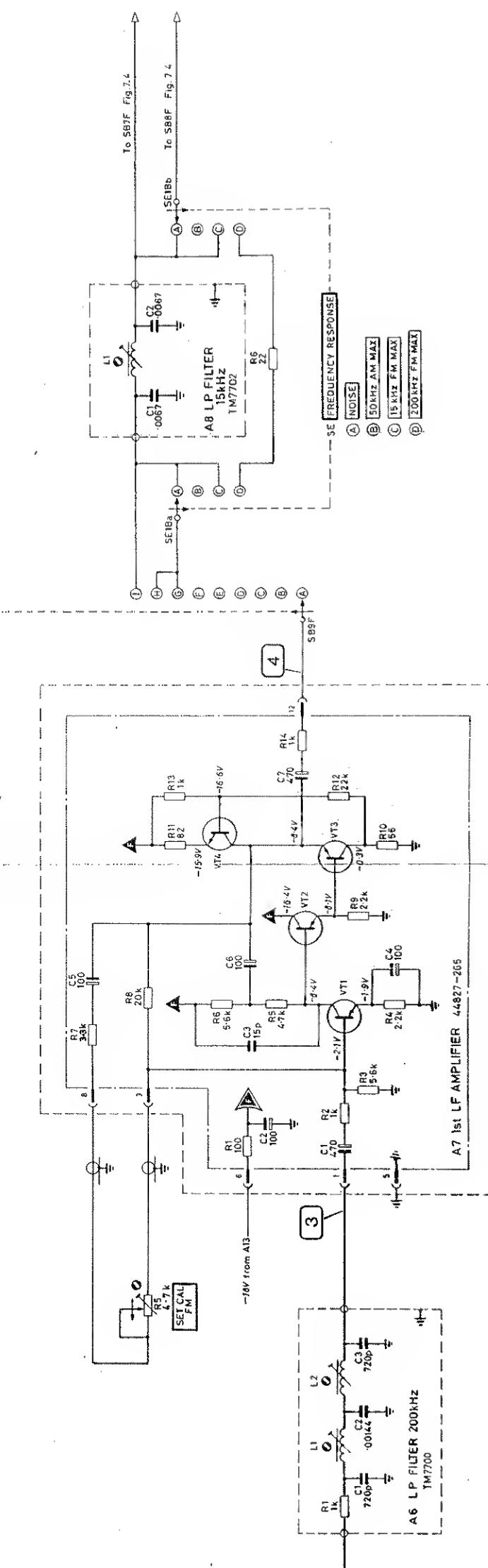
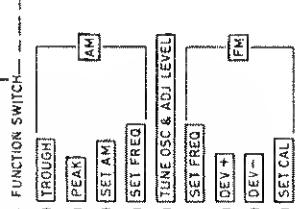
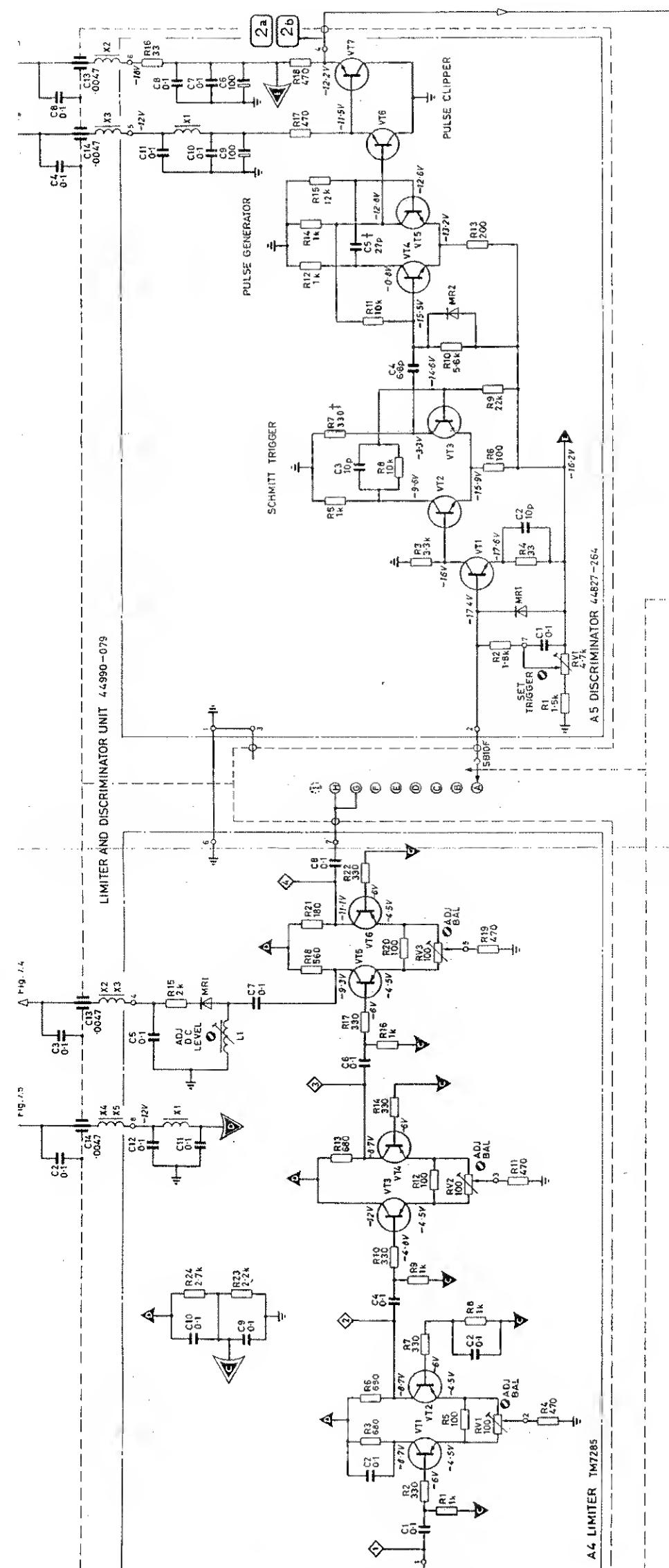


Fig. 7.3 Limiter, discriminator and 1st I.F. amplifier



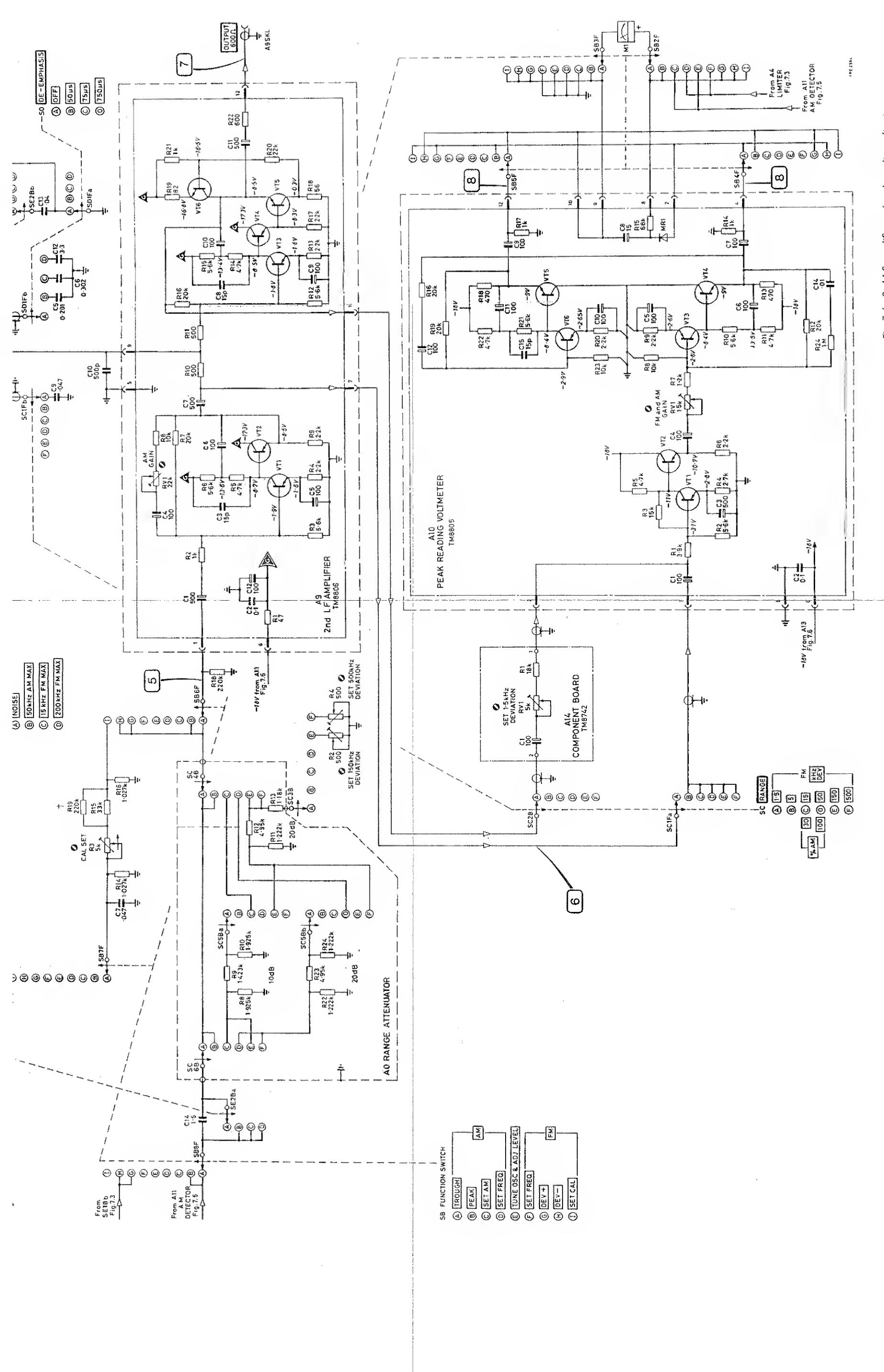


Fig. 7.4 2nd If amplifier and peak reading voltmeter



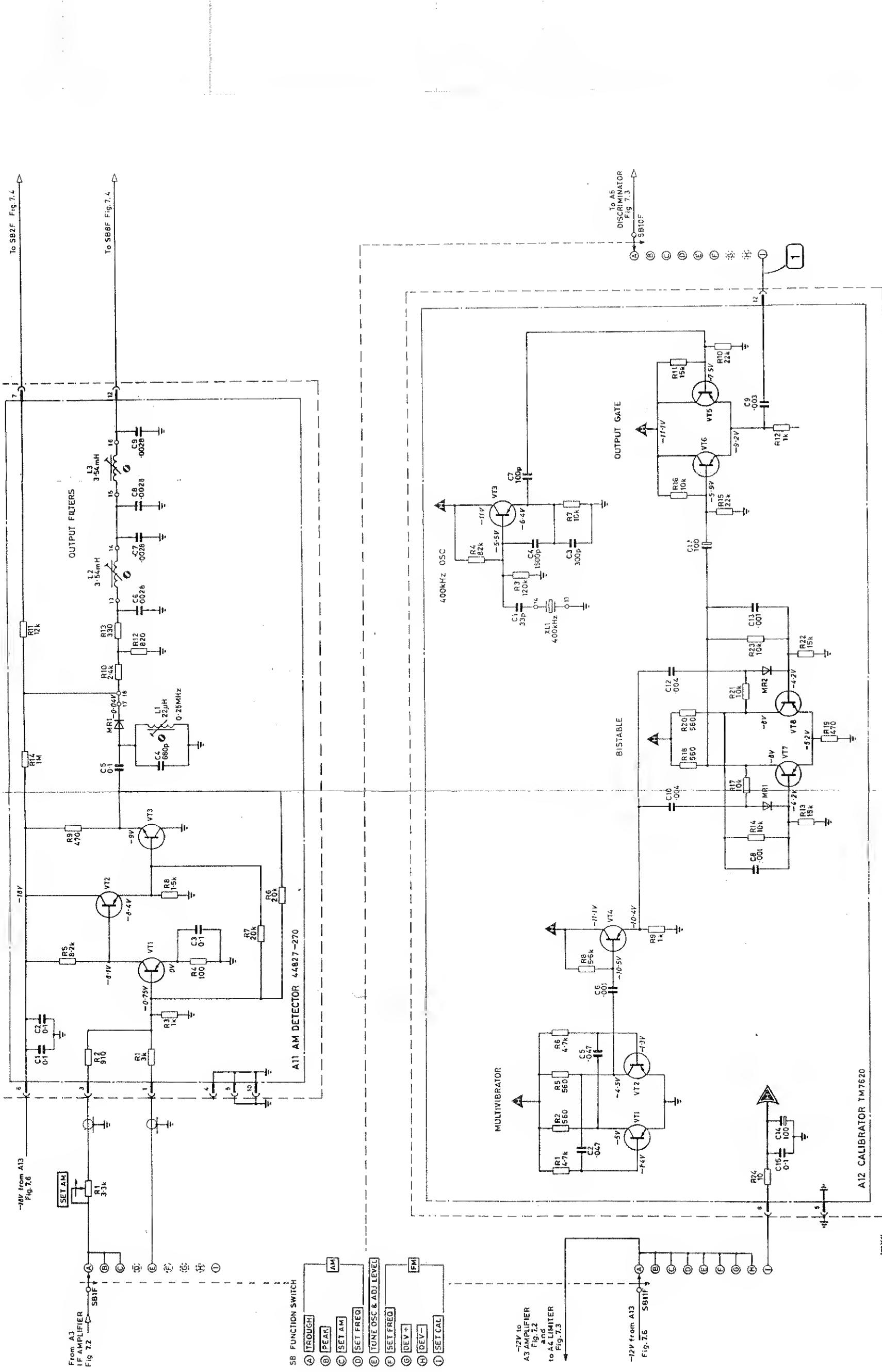


Fig. 7.5 AM detector and calibrator



Fig. 7.6 Power supply unit

